Connecting Rivers, Landscapes, People

Lake Leaghur
Environmental Water Management Plan

NORTH CENTRAL
Catchment Management Authority
Connecting Rivers, Landscapes, People

DOCUMENT CONTROL

Document History and Status

Version	Date Issued	Prepared By	Reviewed By	Date Approved
1	4th April 2016	Peter Rose	Andrew Sharpe	17th April 2016
2	24th May 2016	Peter Rose	Marcus Cooling	
3				
4				

Distribution

Version	Date	Quantity	Issued To
1	4th April 2016	1 (electronic)	Andrew Sharpe
2	24th May 2016	1 (electronic)	Jamie Bell
3			
4			

Document Management

Printed:	23 September 2018
Last saved:	23 September 2018 10:55 PM
File name:	Lake Leaghur EWMP -Final.docx
Authors:	Peter Rose
Name of organisation:	North Central CMA
Name of document:	Lake Leaghur Environmental Water Management Plan
Document version:	Final
SharePoint link:	Lake Leaghur EWMP -Final

For further information on any of the information contained within this document contact:

North Central Catchment Management Authority
PO Box 18
Huntly Vic 3551
T: 03 5448 7124 F: 03 5448 7148
E: info@nccma.vic.gov.au
www.nccma.vic.gov.au

Please cite this document as: North Central CMA, 2016. *Lake Leaghur Environmental Water Management Plan*. North Central Catchment Management Authority, Huntly, Victoria.

EXECUTIVE SUMMARY

The Lake Leaghur Environmental Water Management Plan (EWMP) sets out the long-term objectives for the priority environmental values of Lake Leaghur, in the Wandella Creek sub-catchment of the Loddon River basin. The EWMP is an important part of the Victorian Environmental Water Planning Framework. It provides the five to ten year management intentions, based on scientific information and stakeholder consultation, which can be used by the respective agencies: North Central Catchment Management Authority (CMA), Department of Environment, Land, Water and Planning (DELWP) and the Victorian Environmental Water Holder (VEWH); for both short and longer-term environmental water planning.

This EWMP is not a holistic management plan, but is focused on environmental water management so that Lake Leaghur can continue to provide environmental, social, cultural and economic values for all users. Actions such as infrastructure upgrades and pest plant and animal works are documented as complementary to environmental water management in this EWMP.

The following components are the main sections featured in the Lake Leaghur EWMP. A summary of the main conclusions to facilitate appropriate environmental water management into the future are summarised below.

Hydrology and system operations

Prior to regulation of the Loddon River catchment and associated floodplain works, Lake Leaghur would have received intermittent Loddon River floods with flows provided via a breakaway of Wandella Creek. In large floods, flows would have continued from Lake Leaghur through Leaghur state park into the Meran Lakes complex. The development of the Pyramid–Boort Irrigation System in the 1920s/1930s resulted in a significant change to the hydrology of the Lake Leaghur. Historically, the lake was a strategic outfall point for the irrigation supply system and consistently received significant outfalls from channel 2/2, often in excess of 300 ML/year. These outfalls resulted in a more permanent water regime and subsequent shift in its wetland classification from a Deep Freshwater Marsh that periodically dried to a permanent open freshwater wetland with large areas of shallow open water (< 5 m), dead timber, extensive stands of reeds and mature River Red Gums.

Water dependent values

Lake Leaghur is considered a high value wetland due to the significant vegetation communities, flora and fauna species it supports. The main ecological values associated with Lake Leaghur include threatened waterbirds (20 species are recognised under international agreements, federal or state legislation, or are Victorian rare or threatened species); mature River Red Gums; aquatic and amphibious macrophytes that support water bird and frog communities; and a significant Cane Grass population (*Eragrostis australascia*), which is listed as vulnerable in Victoria. In addition to these values, Lake Leaghur is a priority wetland because of its rehabilitation potential.

Ecological condition and threats

The altered water regime at Lake Leaghur has changed the system from a Deep Freshwater Marsh that supported River Red Gums throughout the wetland floor, to a permanent open freshwater wetland. Despite being dry for most of the Millennium Drought, Lake Leaghur supported a large diversity and abundance of waterbirds during the last wet phase (2011-2014) and River Red Gums are considered to be in moderate condition.

Management actions for Lake Leaghur focus on providing conditions that facilitate River Red Gum growth and recruitment, and maintaining appropriate extents of diverse habitats to support waterbirds. Key threats to condition include the ability to deliver environmental water, encroachment of weeds such as African Boxthorn and Sharp Rush, populations of introduced fauna species (carp and foxes), and the potentially depleted native plant seedbank.

Management objectives

A long-term management goal has been defined for Lake Leaghur.

Management goal:

To provide a water regime that supports flora and fauna that are typical of a Deep Freshwater Marsh, in particular providing key waterbird habitat (breeding and nesting) within a Red Gum Swamp (EVC 292).

The ecological objectives and hydrological objectives that sit under the long-term management goal for Lake Leaghur were informed by the *Lake Leaghur Environmental Watering Plan 2015* and other technical investigations and were refined during the development of this EWMP.

Managing risks to achieving objectives

Effective management of Lake Leaghur requires a holistic approach that provides an appropriate water regime and addresses a range of critical non-flow related factors. External to the delivery of water, the main factors that may prevent the environmental objectives described in this EWMP from being met include: 1) the potential for proliferation and encroachment of native species such as Cumbungi (*Typha spp.*) and Common Reed (*Phragmites australis*); and 2) impacts associated with feral pests such as carp, foxes and rabbits.

Environmental water delivery infrastructure

Previous water delivery infrastructure via the channel 2/2 was considered adequate to deliver the desired water regime (i.e. 60 ML/day, filling the wetland in approximately 11 days). However, in 2013, 7.5 km of this channel was rationalised as part of the GMW Connections Project. Two options are currently being investigated to enable water to be delivered at a sufficient rate (60 ML/day). The preferred option is the continued use of the now private channel 2/2, whereby GMW would provide access to the irrigation network for four weeks prior to and four weeks after the irrigation season; and a restrictive easement would be placed on the channel to ensure maintenance of access and conditions.

Demonstrating outcomes

Monitoring is required to determine the effectiveness of any environmental water that is delivered to Lake Leaghur and to inform the adaptive management of future environmental water allocations at the site. Effective monitoring is also required to enable the CMA and VEWH to demonstrate the long-term outcomes of the implementation of the Lake Leaghur EWMP. A suite of intervention and long-term monitoring activities that will meet the monitoring requirements are recommended.

Consultation

Key stakeholders, including DELWP, Parks Victoria and Goulburn Murray Water (GMW) were engaged during the development of this EWMP. Community consultation for the EWMP consisted of phone conversations with the community members originally consulted for the EWP, specifically focussing on changes to the Lake over the last 5 years.

Knowledge gaps

The management actions in the Lake Leaghur EWMP are based on the best available information. Key knowledge gaps are around the water delivery arrangements for Lake Leaghur given the rationalisation of the channel 2/2, and the ecological responses and impacts from providing an alternative supply point. The fauna that use the wetland during wet phase (particularly frog and turtle species), the viability of the seedbank, and up-to date ecological condition of the wetland are also significant knowledge gaps.

ACKNOWLEDGEMENTS

The information contained in the Lake Leaghur EWMP has been sourced from a variety of reports and field inspections and from individual knowledge and expertise. The North Central CMA acknowledges the assistance of the following people in preparing this EWMP and previous Lake Leaghur EWP, which the EWMP was largely based on:

- Rob O'Brien (Department of Primary Industries)
- Cherie Campbell, Caitlin Johns, Christine Reid and Dr Todd Wallace (Murray-Darling Freshwater Research Centre)
- Geoff Sainty (Sainty Associates)
- Shelley Heron (Kellogg Brown and Root)
- Mark Reid (DPI Primary Industries Research Victoria)
- Andrea Joyce, Andrea Keleher and Bruce Mathers (Department of Environment, Land, Water and Planning)
- Mark Tscharke (Parks Victoria)
- Paul Haw and Rod Stringer (community representatives)
- Ian Lanyon, Murray Lanyon, Graham Lehmann, Ken Buchanan, Ron Bramley (landholders)
- Laurence Cameron (G-MW)
- Mark Daley (Field and Game Australia)
- Pat Feehan (Feehan Consulting)
- Ross Plunkett, Chris Solum Mark Paganini, and Ed Thomas (Goulburn Murray Water)
- Goulburn Murray Water Connections Project Technical Advisory Committee
- Wetland workshop attendees
- Graham Hall, Bridie Velik-Lord, Rebecca Horsburgh, Peter McRostie, Lyndall Rowley, Emer Campbell, Bree Bisset, Louissa Rogers and Michelle Maher (North Central CMA).

ACKNOWLEDGEMENT OF COUNTRY

The North Central Catchment Management Authority acknowledges Aboriginal Traditional Owners within the region, their rich culture and spiritual connection to Country. We also recognise and acknowledge the contribution and interest of Aboriginal people and organisations in land and natural resource management.

CONTENTS

TABLES

FIGURES

1. Introduction

Lake Leaghur is a 59 ha wetland on the floodplain of the Loddon River, located within the Lake Leaghur Wildlife Reserve, 16 km north of Boort. The wetland was maintained as a semi-permanent wetland for much of the 20th century when it was operated as an outfall for the Pyramid-Boort irrigation system. Improvements in irrigation water management and efficiency resulted in Lake Leaghur becoming disconnected from the irrigation network in 2013.

The lake supports important water dependent values and is a high priority to receive environmental water. When flooded, the lake supports large numbers of waterbirds, including international migratory species. The site supports breeding by waterbirds as well as rare and threatened plant species. Lake Leaghur is a rare opportunity to rehabilitate a Deep Freshwater Marsh habitat.

This plan sets out the basis for delivering environmental water to Lake Leaghur including the physical environment, conservation values, ecological objectives, recommended water regime and operational arrangements.

Management of environmental water is planned and implemented through a framework of key documents. Figure 1 illustrates the strategies, scientific reports and operational documents required for environmental water management in Victoria. The North Central Catchment Management Authority (CMA) has recently developed the *North Central Waterway Strategy 2014-2022* (NCWS) which is an integrated strategy aimed at managing and improving the North Central CMA's waterways (rivers, streams and wetlands). The NCWS is guided by the *Victorian Waterway Management Strategy 2013* (VWMS) and the *North Central Regional Catchment Strategy 2012* (RCS). The NCWS sets priorities and outlines a regional works program to guide investment over the next eight years (North Central CMA 2014).

Lake Leaghur is identified as a priority wetland in the NCWS. The NCWS aims to influence long-term resource condition of waterways throughout the region by:

- Maintaining and improving the condition of the Mid-Loddon wetlands by 2050 as measured by Index of Wetland Condition.
- Increasing the species richness of wetland-dependent bird species across the Boort Wetlands to 30 by 2020 and the number of individuals to an average of 1000 - as measured by monthly counts during a wet phase.

These targets are reflected in the overall management goals and objectives described by this EWMP (Section 6). A number of management activities are recommended to achieve these targets. Specific management activities include pest plant and animal control, appropriate delivery of environmental water, and ecological monitoring and assessments to improve knowledge of the wetland. The North Central CMA will deliver these activities in partnership with Parks Victoria (PV), Goulburn Murray Water (GMW), the Victorian Environmental Water Holder (VEWH), the Department of Environment, Land, Water and Planning (DELWP) and local landholders.

The North Central CMA has received funding through DELWP 'Victorian Basin Plan Environmental Water Management Plan Program' to prepare an EWMP for Lake Leaghur. This EWMP aims to establish the long-term environmental water management goals for Lake Leaghur to guide future management.

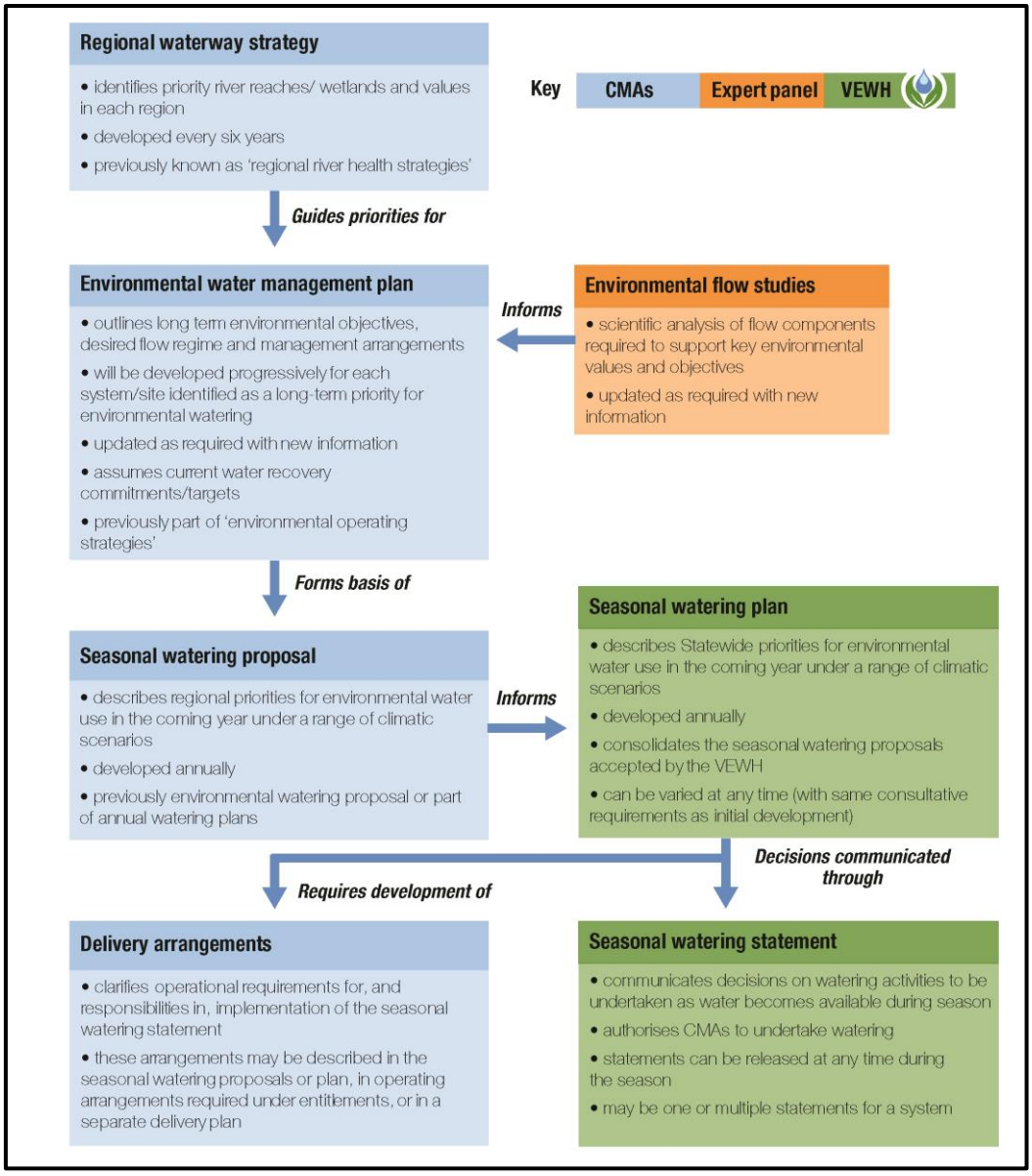


Figure 1. Planning framework for decisions about environmental water management in Victoria. Source: VEWH (2016).

1.1. Purpose and scope

The Lake Leaghur EWMP is a ten year management plan that describes the ecological values present, the long-term goal for the wetland, priority ecological objectives, and the watering regime required to achieve these objectives. It is based on scientific information and stakeholder consultation and will be used by the North Central CMA when planning environmental water use. DELWP and the VEWH will also use the EWMP for short and longer-term environmental water planning (Department of Environment and Primary Industries [DEPI] 2014a).

The key purposes of the EWMP are to:

- identify the long-term objectives and water requirements for the wetland;
- provide a vehicle for community consultation, including for the long-term objectives and water requirements of the wetland;
- inform the development of future Seasonal Watering Proposasls (SWPs) and seasonal watering plans; and

- inform Long-term Watering Plans that will be developed by the State under the Murray-Darling Basin Plan Chapter 8 (DEPI 2014a).

The focus of this EWMP is the entirety of Lake Leaghur (wetland area approx. 59 ha), which is currently managed by Parks Victoria.

1.2. Development Process

Lake Leaghur has an Environmental Watering Plan (EWP) that was prepared by the North Central CMA under the Goulburn Murray Water Connections Project (formerly the Northern Victoria Irrigation Renewal Project) and finalised in early 2015. The purpose of the EWP was to establish a volume of mitigation water that Goulburn Murray Water Connections Project was required to set aside to address potential environmental impacts caused by reduced outfalls to Lake Leaghur. The EWP established ecological objectives and a watering regime for Lake Leaghur.

The Lake Leaghur EWMP is based on work undertaken for, and presented in, the *Lake Leaghur Environmental Watering Plan 2015*, and was developed in collaboration with key stakeholders including DELWP, Parks Victoria, VEWH, Goulburn Murray Water (GMW) and local landholders. A number of tasks were undertaken to convert the EWP to an EWMP including:

- **Collation of flora and fauna records:** Species lists and status were updated with new records from relevant databases and surveys.
- **Collation of surface water quality data and groundwater data**
- **Community and stakeholder consultation**: The original community and stakeholder group was consulted to provide input into the draft EWMP, particularly relating to the water management goal, ecological objectives and optimum watering regime. See 0 for further details.

Information from the above tasks was analysed to provide justification and evidence for the following sections of the EWMP:

- **Water dependent values:** Environmental values were derived from the baseline flora and fauna surveys, historical reports, DELWP databases and community and stakeholder accounts. Terrestrial species that, due to large-scale clearing of woodland habitat throughout the catchment, are dependent on the vegetation surrounding the wetlands are also documented. Social values (cultural heritage, recreation and economic) are further described.
- **Ecological condition, condition trajectory and threats**: Available information was used to describe the current condition and water related threats to Lake Leaghur. A "do-nothing" scenario is further considered to understand the condition trajectory if no action is undertaken.
- **Management objectives**: The water management goal and the ecological objectives for Lake Leaghur are based on the water dependent values recorded for the wetland, the current condition and the condition trajectory. The objectives are also aligned with the broader environmental outcomes proposed in the *Basin Plan draft Environmental Watering Strategy 2014*.
- **Managing risks:** The risks to achieving the ecological objectives for Lake Leaghur are based on the best-available scientific and local knowledge. Management actions to mitigate each risk have been recommended and residual risk (assuming full adoption of management action) identified.

- **Environmental water delivery infrastructure:** Current constraints to delivery of environmental water are identified as well as recommendations to allow future environmental water delivery.
- **Demonstrating outcomes**: Monitoring to adaptively manage the delivery of environmental water and to demonstrate the outcomes against the ecological objectives are based on best available science monitoring method. Justification for a suite of long term and intervention monitoring recommendations are given.
- **Knowledge gaps and recommendations:** A number of knowledge gaps were identified during the process of developing the ecological objectives, management actions and risk analysis sections of the EWMP. A series of activities to address the knowledge gaps are identified and ranked.

2. Site overview

2.1. Site location

Lake Leaghur is situated approximately 16 km north of the township of Boort and 3 km west of the Loddon River (Figure 2). It is located in the Wandella Creek sub-catchment of the Loddon River basin.

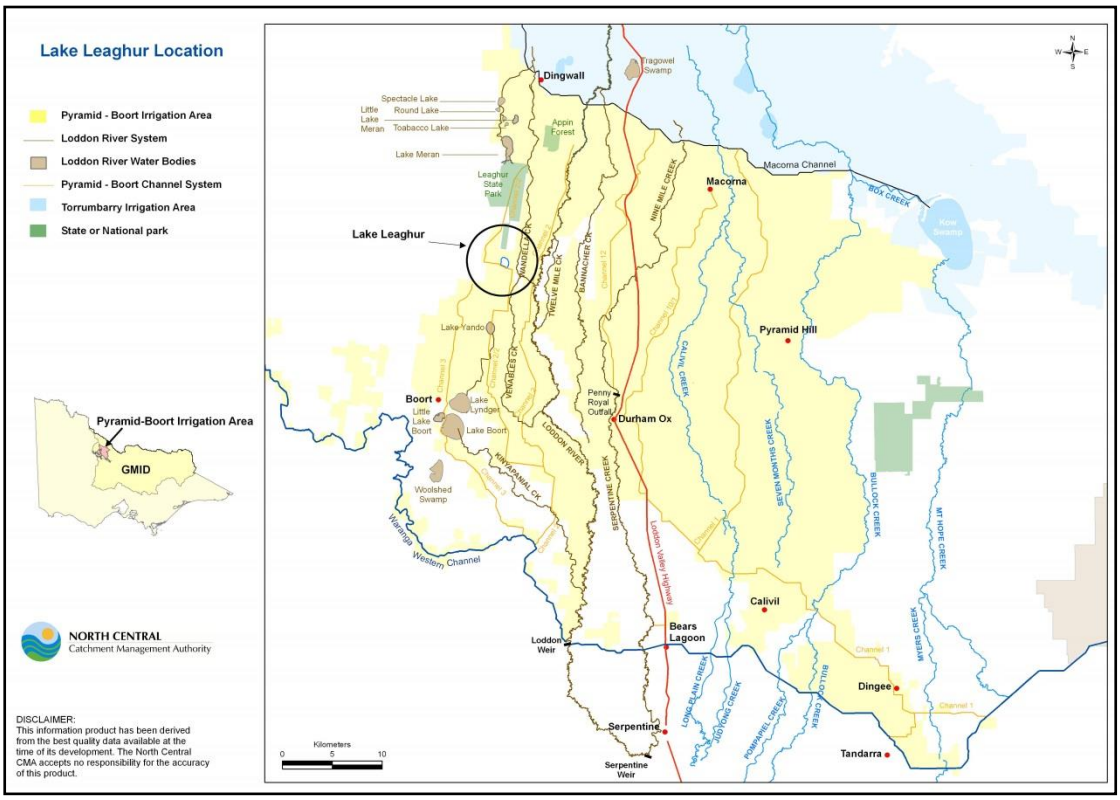


Figure 2. Map of the lower Loddon River catchment showing the location of Lake Leaghur

2.2. Catchment setting

Climate

Rainfall in the Boort region averages 394 mm/year, with May to October being significantly wetter months than November to April (Bureau of Meteorology 2009). Maximum average daily temperatures range from 31.3 °C in January to 13.9 °C in July; average minimum average daily temperatures fall below 5 ^{o}C between June and August (Bureau of Meteorology 2009).

Hydro-physical characteristics

Lake Leaghur forms part of the broader Boort district wetlands within the Loddon floodplain. The Boort district wetlands consist of six regionally significant wetlands (Lake Leaghur, Lake Yando, Lake Boort, Little Lake Boort, Lake Meran and Little Lake Meran) that were predominantly Redgum Swamps prior to European settlement. Lake Leaghur is situated within the Victorian Riverina bioregion, an area that is characterised by a flat to gently undulating landscape on recent unconsolidated sediments. Flows paths across the bioregion have changed frequently over relatively recent geological timescales and since European occupation. There is considerable evidence of former stream channels and wide floodplain areas associated with major river systems and prior streams (DEPI, 2016). Red brown earths and texture contrast soils (Chromosols and Sodosols) derived from alluvium deposits from the Cainozoic period dominate the riverine plain (DEPI, 2016). Lake Leaghur sits high in the landscape and as such receives little drainage runoff from the surrounding land. The construction of levees in the first half of the 20th Century further disconnected

the wetland from its local catchment (SKM 2001). Figure 3 shows the natural topography of the area and the location of Lake Leaghur within the broader Boort wetland complex.

Lake Leaghur is completely contained within a 79 ha Crown land reserve (DCE 1991). It has an oval shape and a relatively flat bottom. At full supply level (FSL 85.85 m AHD), Lake Leaghur has a capacity of 664 ML, a surface area of approximately 59 ha and a maximum depth of 1.35 m (Price Merrett Consulting 2006). Refer to Appendix 2 for the contour plan prepared for Lake Leaghur by Price Merrett Consulting (2006).

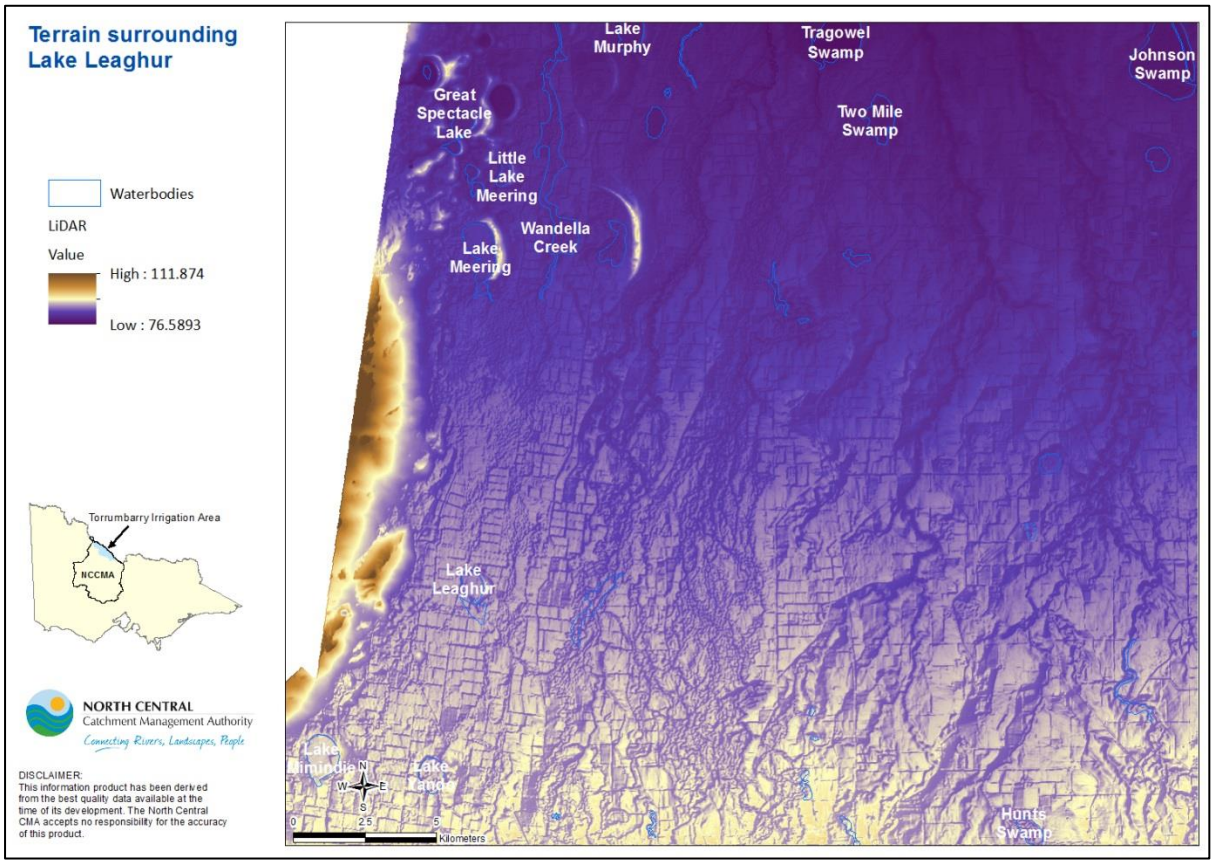


Figure 3. Terrain of the Loddon River floodplain surrounding Lake Leaghur

2.3. Land status and management

Land use

The surrounding land use is agricultural dominated by cropping. Lake Leaghur is connected to a remnant patch of woodland to the southeast and to Leaghur State Park to the north, although the connection to the southeast is narrow and fragmented for the first 800 m (Campbell et al. 2009).

Land tenure

Lake Leaghur occupies approximately 59 ha of the 79 ha Lake Leaghur Wildlife Reserve (hunting), managed by Parks Victoria. Wildlife reserves are managed to conserve and protect species, communities or habitats of indigenous animals and plants while permitting recreational activities (including hunting in season as specified by the land manager) and educational use (VEAC 2008; DSE 2009c).

There are several agencies directly involved in environmental water management in Victoria. Other agencies, such as public land managers, play an important role in facilitating the delivery of environmental watering outcomes. .

Table 1 describes the key stakeholders that manage Lake Leaghur.

Table 1. Roles and responsibilities for environmental water in Lake Leaghur

Agency/group	Responsibilities/involvement
Department of Environment, Land, Water and Planning (DELWP)	- Manage the water allocation and entitlements framework - Develop state policy on water resource management and waterway management for approval by the Minister for Environment, Climate Change and Water - Develop state policy for the management of environmental water in regulated and unregulated systems - Act on behalf of the Minister for Environment, Climate Change and Water to maintain oversight of the VEWH and Waterway Managers (in their role as Environmental Water Managers) - Legislative responsibilities for the management of flora and fauna - Approve EWMPs and endorse SWPs.
Victorian Environmental Water Holder(VEWH)	- Make decisions about the most effective use of the Water Holdings, including use, trade and carryover - Authorise waterway managers to implement watering decisions - Liaise with other water holders to coordinate use of all sources of environmental water - Publicly communicate environmental watering decisions and outcomes - Prepare the State-wide Seasonal Watering Plan - Provide final endorsement of Seasonal Watering Proposal - Approve delivery of environmental water (Seasonal Watering Statement) and fund environmental water related monitoring.
Commonwealth Environmental Water Office (CEWO)	- Make decisions about the use of Commonwealth water holdings, including providing water to the VEWH for use in Victoria. - Liaise with the VEWH to ensure coordinated use of environmental water in Victoria - Report on management of Commonwealth water holdings.
Murray-Darling Basin Authority (MDBA)	- Implement the Murray-Darling Basin Plan - the Basin Plan sets legal limits on the amount of surface water and groundwater that can be taken from the Basin from 1 July 2019 onwards - Coordinate and integrate water resource management across the Murray-Darling Basin
North Central Catchment Authority (North Central CMA)	- Waterway Manager - Identify regional priorities for environmental water management in regional waterway strategies - In consultation with the community, assess environmental water requirements of priority rivers and wetlands to meet agreed objectives and implement environmental works to use environmental water more efficiently - Propose annual environmental watering actions to the VEWH and implement the VEWH environmental watering decisions - Provide critical input to manage other types of environmental water (passing flows management, above cap water) and report on environmental water management activities undertaken.

Agency/group	Responsibilities/involvement
Goulburn Murray Water (GMW)	- Water Corporation – Storage Manager and Resource Manager - Work with the VEWH and Waterway Managers to plan for the delivery of environmental water to maximise environmental outcomes - Operate water supply infrastructure such as dams and irrigation distribution systems to deliver environmental water - Ensure the provision of passing flows and compliance with management of diversion limits in unregulated and groundwater systems - Endorse SWP and facilitate on-ground delivery.
Parks Victoria	- Land Manager - Implement the relevant components of EWMPs. - Operate, maintain and replace, as agreed, the infrastructure required to deliver environmental water, where the infrastructure is not part of the GMW irrigation delivery system. - Where agreed, participate in the periodic review of relevant EWMPs and endorse SWPs - Manage and report on other relevant catchment management and risk management actions required due to the implementation of environmental water.
Input, advice and interest in environmental watering	
Wamba Wamba, Barapa Barapa and Wadi Wadi Peoples Native Title Claimants	- Traditional owners of the area encompassing Lake Leaghur
Loddon Environmental Water Advisory Group (EWAG)	- Stakeholder and community group developed to provide advice on the best use of environmental water in the Loddon catchment, including Lake Leaghur.

2.4. Wetland characteristics

Victoria's wetland classification and inventory was updated in 2013 and replaces the system developed by Corrick and Norman in the early 1980s. The updated classification is based on the Australian National Aquatic Ecosystem (ANAE) Classification Framework (the Framework) and converts data on wetlands and their classification attributes into spatial Geographic Information System (GIS) layers.

The Framework structure produces 37 wetland types based on a hierarchical classification. The first classification level distinguishes between naturally-occurring and human-made wetlands. The second classification level distinguishes between aquatic ecosystem habitats: palustrine, lacustrine and estuarine wetlands. The third classification level distinguishes wetlands based on the following attributes: water regime, salinity, landscape context, soils and wetland vegetation (DEPI 2014b).

Under Corrick and Norman, the pre-European classification (1750 Classification) for Lake Leaghur was a Deep Freshwater Marsh. Due to extensive irrigation outfalls throughout the 20th century, it was re-classified as permanent open water (1994 Classification). Based on the 2014 classification system, Lake Leaghur is a naturally occurring temporary freshwater lake (DEPI 2014b). An overview of the wetland characteristics of Lake Leaghur is provided in Table 2.

Table 2. Wetland characteristics of Lake Leaghur

Characteristics	Description	
Name	Lake Leaghur	
Mapping ID (Corrick)	7626 524142	
Area (ha)	Reserve	79 hectares
	Wetland (Lake Leaghur)	59 hectares
Bioregion	Victorian Riverina	
Conservation status	Regionally significant wetland	
Land status	Crown land reserve	
Land manager	Parks Victoria	
Surrounding land use	Horticulture	
Water supply	• Natural: Wandella Creek and Loddon River • Current: No current water supply	
1788 wetland category (Corrick and Norman)	Deep Freshwater Marsh (inundated >8 months per year, <2 m depth)	
1994 wetland category (Corrick and Norman)	Category: Permanent Open Freshwater Sub-category: shallow (<5 m), Dead Timber, Reed, Red Gum	
2013 Victorian wetland classification (DEPI 2014b)	*Wetland ID: 43171* *Aquatic System:* Lacustrine *Salinity Regime:* Fresh *Water regime:* Periodically Inundated - Intermittent *Water Source – Tidal:* Non-tidal *Water Source – River:* Very high *Water Source – Groundwater: Moderate* *Water Source – Artificial:* Artificial *Wetland Origin:* Naturally occurring *Wetland Type:* Temporary freshwater lakes	
Wetland capacity	664.24 ML, FSL 85.85 m AHD	
Wetland depth at capacity	1.35	

2.5. Environmental water sources

The environmental water that is available for use at Lake Leaghur is derived from a number of sources, described below and in Table 3. Water shares are classed by their reliability and there are two types in Victoria:

- High-reliability water shares (HRWS), which is a legally recognised, secure entitlement to a defined share of water.
- Low reliability water shares (LRWS) which are water shares with a relatively low reliability of supply. Allocations are made to high-reliability water shares before low-reliability shares (DEPI 2014c).

Water availability can vary from season to season according to climatic conditions, volumes held in storages and carryover entitlements.

Bulk Entitlement (River Murray Flora and Fauna) Conversion Order 1999

The Victorian River Murray Flora and Fauna Bulk Entitlement provides 27,600 ML HRWS in the Murray System. It is held by the VEWH for the purpose of providing for flora and fauna needs. It can also be traded on the water market on an annual basis. The use of this water in Lake Leaghur is not guaranteed and is at the discretion of the VEWH (VEWH 2012).

Commonwealth Water Holdings

Commonwealth water holdings are the direct result of government purchases of entitlements and a substantial investment in more efficient water infrastructure in the Murray Darling Basin. As at 25

March 2015, the Commonwealth environmental water holdings totalled 3,397 ML for the Loddon River system and 310,217 ML for the Murray River system. The use of this water for wetlands in the North Central CMA region is not guaranteed and is at the discretion of the Commonwealth Environmental Water Office (CEWO 2016).

GMW Connections Project – Environmental Entitlement (Murray System)

The Goulburn-Murray Water Connections Project is an irrigation modernisation project that aims to improve water delivery across northern Victoria. While improving irrigation efficiency, the Connections Project will reduce outfall volumes to wetlands, including Lake Leaghur. 'Mitigation water' will be provided to wetlands to ensure there is no net impact on high environmental values. The *Lake Leaghur Environmental Watering Plan 2015* determined that 58 ML of mitigation water needed to be set aside for Lake Leaghur each year. More details on the justification for mitigation water and specific calculations for the mitigation volume for Lake Leaghur are presented in NCCMA (2015a).

Table 3. Environmental water sources for Lake Leaghur

Water entitlement	Volume	Flexibility of management	Conditions on availability and use	Responsible agency
Bulk Entitlement (River Murray – Flora and Fauna) Conservation Order 1999	28,750 ML (high reliability) 3,893 ML (low reliability) Carryover determined by VEWH	Fully flexible management	Can be used across multiple systems, within relevant trade protocols	VEWH
	40,000 ML (unregulated flows)	Flexible management in declared periods only	Only available for use during declared periods of unregulated flows on the Murray system	VEWH
Environmental Entitlement (Murray System - NVIRP Stage 1) 2012 'mitigation water'	58 ML for Lake Leaghur	Can only be used in wetlands that have an approved Environmental Watering Plan with mitigation water recommended, such as Lake Leaghur.		VEWH
Commonwealth Water Holdings	Determined by CEWO	Agreement is required with the CEWO	Can be used across multiple systems, within relevant trade protocols	CEWO (facilitated through VEWH)

2.6. Related agreements, legislation, policy, plans and activities

There are a range of international treaties, conventions and initiatives, as well as National and Victorian State Acts, policies and strategies that direct the management of wetlands within Victoria. Those of particular relevance to the management of the environmental and cultural values at Lake Leaghur are listed below. The function and major elements of each treaty, convention and initiative is presented Appendix 1.

International treaties, conventions and initiatives:

- Japan Australia Migratory Birds Agreement (JAMBA) 1974 - six species listed under this agreement have been recorded at Lake Leaghur.
- China Australia Migratory Birds Agreement (CAMBA) 1986 – seven species listed under this agreement have been recorded at Lake Leaghur.
- Republic of Korea Australia Migratory Birds Agreement (ROKAMBA) 2002 - five species listed under this agreement have been recorded at Lake Leaghur.

- Convention on the Conservation of Migratory Species of Wild Animals (Bonn Convention) 1979 – seven species listed under this convention have been recorded at Lake Leaghur.

Commonwealth legislation and policy:

- Aboriginal and Torres Strait Islander Heritage Protection Act 1984 (Part IIA) – Lake Leaghur is an area of cultural sensitivity.
- Environment Protection and Biodiversity Conservation Act 1999 (EPBC Act) – two species listed under this Act have been recorded at Lake Leaghur. This act also covers migratory species.
- Water Act 2007 – to provide for the protection of ecological values at Lake Leaghur through appropriate management of Murray-Darling Basin water resources.

Victorian legislation:

- Aboriginal Heritage Act 2006 –Lake Leaghur is an area of cultural sensitivity.
- Catchment and Land Protection Act 1994 - governs the management of land surrounding Lake Leaghur e.g. pest plant and animal control.
- National Parks Act 1975 – Wildlife Reserves
- Wildlife Act 1975 - Parks Victoria manages Lake Leaghur in accordance with this Act.
- Water Act 1989 - provides a formal means for the integrated management of water in Victoria.
- Flora and Fauna Guarantee Act 1988 (FFG Act) - thirteen fauna species and seven flora species listed under this Act have been recorded at Lake Leaghur.

National policies and strategies:

- The National Cultural Flows Research Project – this project is investigating indigenous water values and uses to form the basis for cultural flow water entitlements. These would be legally and beneficially owned by the Indigenous Nations and are of a sufficient and adequate quantity and quality to improve the spiritual, cultural, environmental, social and economic conditions of those Indigenous Nations. The cultural flows framework is under development but may influence Lake Leaghur as it is an area of cultural sensitivity.

Victorian policy and strategies:

- Victorian threatened flora and fauna species (DEPI advisory lists) – twenty-seven fauna species and 6 flora species on the DEPI advisory lists have been recorded at Lake Leaghur.
- Victorian Waterway Management Strategy (VWMS) – this strategy outlines the direction for the Victorian Government's investment over an eight year period (beginning in 2012-13). The overarching management objective is to maintain or improve the environmental condition of waterways to support environmental, social, cultural and economic values (DEPI 2013a).

Regional strategies and plans:

- North Central Regional Catchment Strategy (RCS) (North Central CMA 2012) sets regional priorities for the management of natural assets, and sets overall direction for investment and coordination of effort by landholders, partner organisations and the wider community for 2013-2019. The Boort District Wetlands are identified as a key priority wetland asset in the RCS that supports highly depleted wetland types and significant threatened flora and fauna speices.

- North Central Waterway Strategy (NCWS) (North Central CMA 2014) is an action out of the Victorian Waterway Management Strategy and provides the framework for managing rivers and wetlands with the community over the next eight years. It delivers key elements of the VWMS including developing work programs to maintain or improve the environmental condition of waterways in the North Central region. Lake Leaghur is a priority wetland for this eight year planning period.

3. Hydrology and system operations

Wetland hydrology is the most important determinant of wetland types and wetland processes. It affects the chemical and physical aspects of the wetland which in turn affects the types of flora and fauna that the wetland supports. A wetland's hydrology is determined by surface and groundwater inflows and outflows, precipitation and evapotranspiration (Mitsch & Gosselink 2000). Duration, frequency and seasonality (timing) are the main components of the hydrological regime for wetlands and rivers.

3.1. Wetland hydrology, water management and delivery

3.1.1. Pre-regulation

Lake Leaghur is situated relatively high in the landscape and therefore receives little runoff from the surrounding area. Prior to river regulation, virtually all of the water in Lake Leaghur would have come from Loddon River floods. Flood waters would have entered Lake Leaghur from the south, via the Wandella Creek breakaway, and surplus water would have flowed out the northern end of the lake and then into Leaghur State Park and Lake Meran (Figure 4). Climate records indicate the Loddon River mainly flooded in winter and spring and therefore Lake Leaghur would have normally filled in those seasons and then drawn down over summer and autumn. Loddon River floods were more frequent than they are now, but they would not have occurred every year.

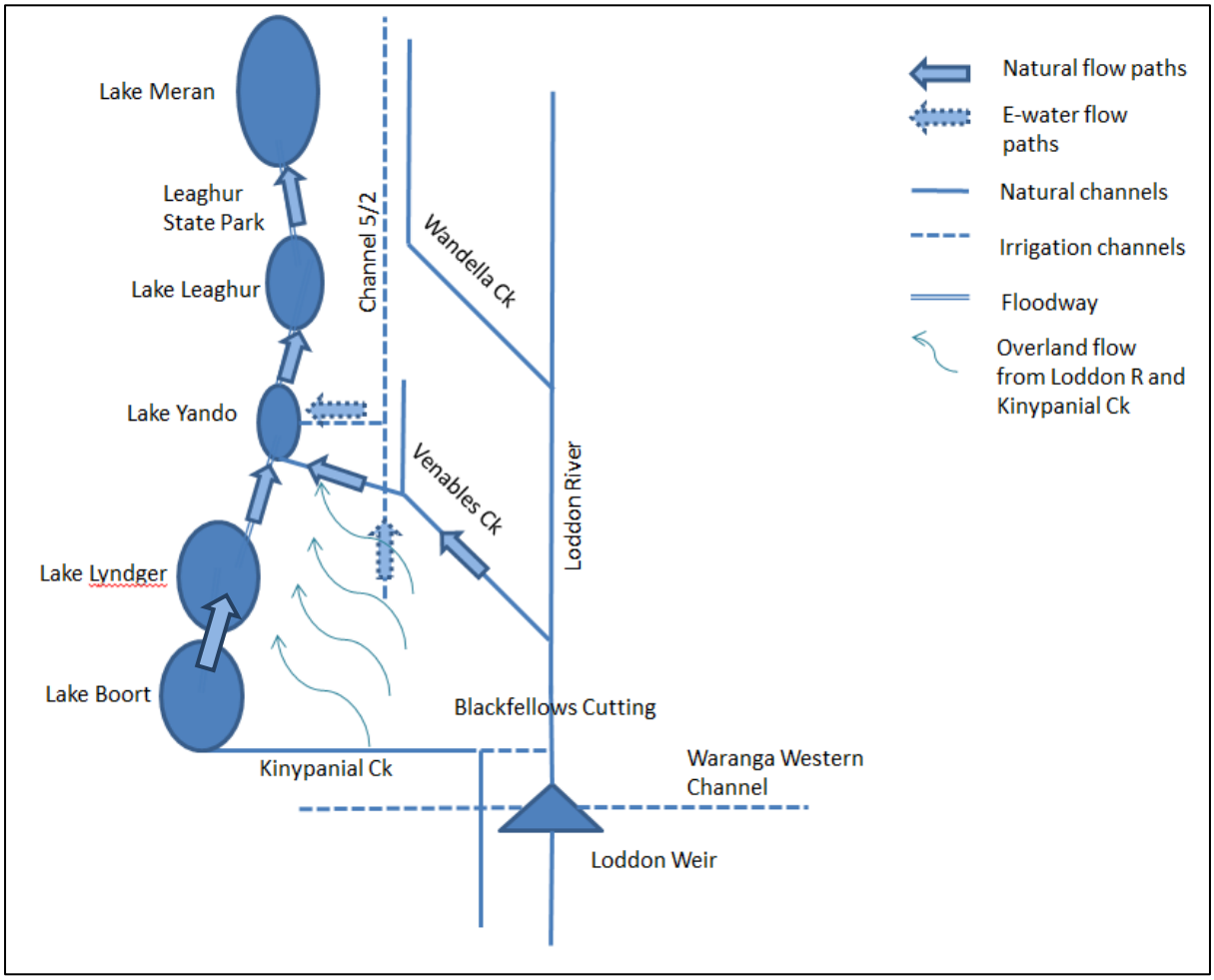


Figure 4. Schematic diagram of flow paths on the Loddon floodplain downstream of Loddon Weir showing Lake Leaghur inflow-outflow paths

3.1.2. Post-regulation

The hydrology of Lake Leaghur was changed as early as the 1840s, when inflows into Lake Leaghur were increased by diverting Loddon River water and raising the outlet to hold water. The development of the Pyramid–Boort Irrigation System in the 1920s/1930s changed the hydrology of much of the Loddon River floodplain including Lake Leaghur. Historically, Lake Leaghur was a strategic outfall point for the irrigation supply system and often received outfalls in excess of 300 ML/year from channel 2/2 (O'Brien and Joyce 2002). These outfalls turned Lake Leaghur from an wetland that periodically dried into a permanent open freshwater wetland that supported shallow open water (< 5 m), dead timber, reeds and River Red Gum vegetation (DSE 2009b). Permanent open freshwater wetlands retain water for longer than twelve months though they may experience a drying phase during prolonged droughts.

Locals have advised that Lake Leaghur was permanently inundated for much of their living memory up until the late 1990s (Appendix 5). Improved on farm practices and irrigation modernisation works associated with the GMW Connections Project reduced outfalls to Lake Leaghur from the early 2000s (see Figure 5). Surface water data collected by DPI sporadically between 1990 and 2007 shows that Lake Leaghur had very low but fluctuating water levels from November 1997 and completely dried in November 2002.

Table 4 shows the watering history of Lake Leaghur over the last twenty years. Although there have been small volumes of recorded channel outfalls to Lake Leaghur between 2000 and 2009 (Figure 5), Lake Leaghur has been dry since 2000/01 (Table 4). Lake Leaghur received environmental water in Autumn 2010 which was the first time the lake had been filled and flushed since the last flood in 1996 (R O'Brien [DPI] 2010, pers. comm., 8 February). Lake Leaghur was then filled from regional flooding in August to October 2010 (see Figure 6) and again in February 2011 and received environmental water again in the 2012/2013 season. The lake was in a wet phase from 2009/10 until 2013/14, due to the combination of environmental water deliveries and flood events, and has been dry since.

Lake Leaghur is also operated for flood mitigation storage during large natural floods. In these instances, GMW consult with North Central CMA about water diversion to the wetland.

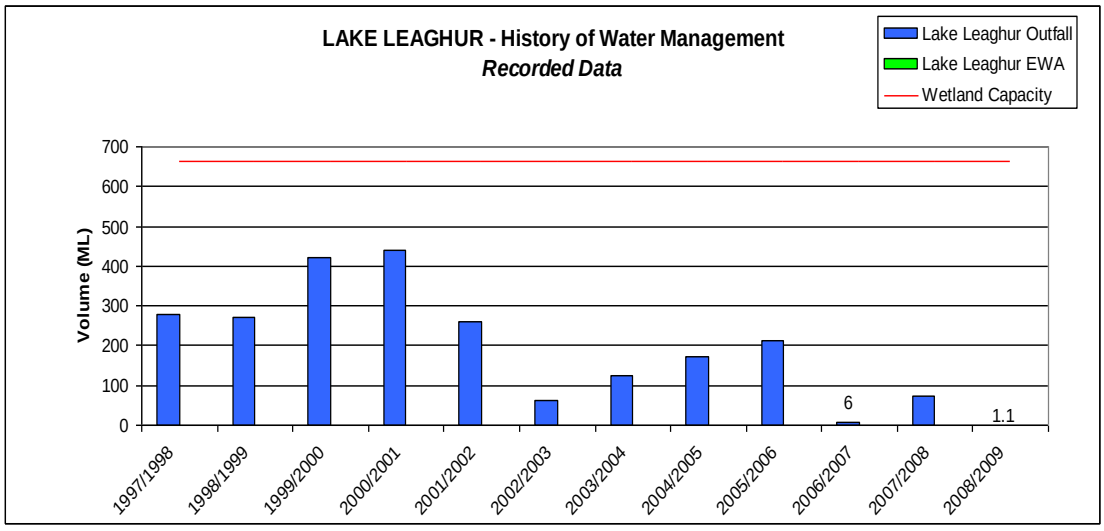


Figure 5. Recorded volumes received by Lake Leaghur from channel outfalls since 1997/1998

Table 4. Lake Leaghur wetting/drying calendar. Source: North Central CMA (2015a)

Watering History	Season									
	1995 - 1996	1996 - 1997	1997 - 1998	1998 - 1999	1999 - 2000	2000 – 2001	2001 - 2002	2002 - 2003	2003 - 2004	2004 - 2005
Status[1]	W	W	W	W	D	D	D	D	D	D
Water source[2]	C	C	C	C	C	C	C	C	C	C
	2005 - 2006	2006 - 2007	2007 - 2008	2008 - 2009	2009 - 2010	2010 - 2011	2011 - 2012	2012 - 2013	2013 - 2014	2014 - 2015
Status[1]	D	D	D	D	D	W	W	W	W/D	D
Water source[2]	-	-	-	-	-	E/I	-	E	-	-

[1] Water present / dry wetland

[2] Environmental water allocation / Flood mitigation / Unknown / Channel outfall / Surplus flows / Flood Inundation/Irrigation Tailwater

Figure 6. Leaghur State Park and Lake Leaghur during natural flooding in 2010

3.1.3. Groundwater/surface water interactions

Bartley (2009) assessed of the risk of groundwater impacts from environmental watering, including the risk of saline groundwater seepage to low-lying land, and the potential for flushing of salts through the bed profile of Lake Leaghur. The information contained in Bartley (2009) is summarised below, and has been updated with more recent data where possible.

Lake Leaghur is situated on the Loddon River floodplain on lower floodplain alluvial sediments. Shepparton Formation and Parilla Sand sediments outcrop 2 km west of the wetland, close to the Leaghur Fault. The alluvial/Shepparton Formation sediments comprise sandy clay and clay, and are approximately 35 m thick at the wetland. These sediments overlie the Parilla Sand and Renmark Group sediments. Groundwater beneath the floodplain west of the Loddon River flows from the south and southeast toward the northeast, north and northwest.

Lake Leaghur would have naturally been intermittently filled by floodwaters and would have been a temporary source of groundwater recharge following flood events. A lunette borders the wetland to the east and indicates a prior period of shallow groundwater levels.

Groundwater level and water quality monitoring at Lake Leaghur is conducted by Department of Economic Development, Jobs, Transport and Resources (DEDJTR). DEDJTR collect groundwater data from regional bores in the State Observation Bore Network and other bores within the vicinity (see Figure 7 for bore locations near Lake Leaghur). Regular monitoring of surface water and electrical conductivity (EC) commenced in 1990 and is also undertaken by DEDJTR.

Regional groundwater levels were shallow between 1980 and 1990; however they have been declining since the 1990s in response to below average rainfall. Figure 8 illustrates groundwater behaviour from bores approximately 1 km east of Lake Leaghur. When the regional groundwater levels were at their highest, groundwater was above the bed of Lake Leaghur (84.5 m AHD). Groundwater discharge into the wetland would have occurred if it did not contain water at the time.

Groundwater levels in the vicinity of the wetland have fluctuated over time. Levels beneath Lake Leaghur began to decline around 1997, which is consistent with the broader regional decline. In March 2009, groundwater levels were at least 4 m below the bed of Lake Leaghur. Bores to the east of Lake Leaghur (Figure 9) currently have a higher groundwater level than those located to the west (Figure 10) reflecting localised impacts from channel outfalls.

Groundwater levels rose significantly in all bores across the region as a result of the 2010/11 floods, but gradually declined between 2011 and 2016 (

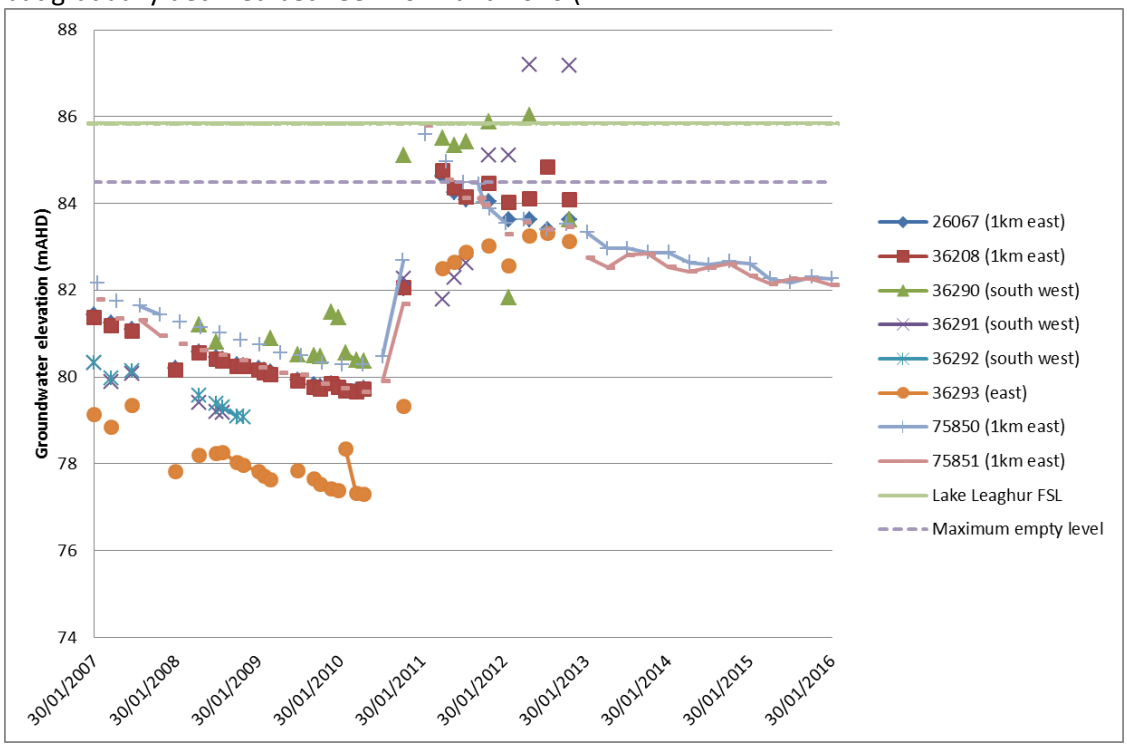


Figure **11**).

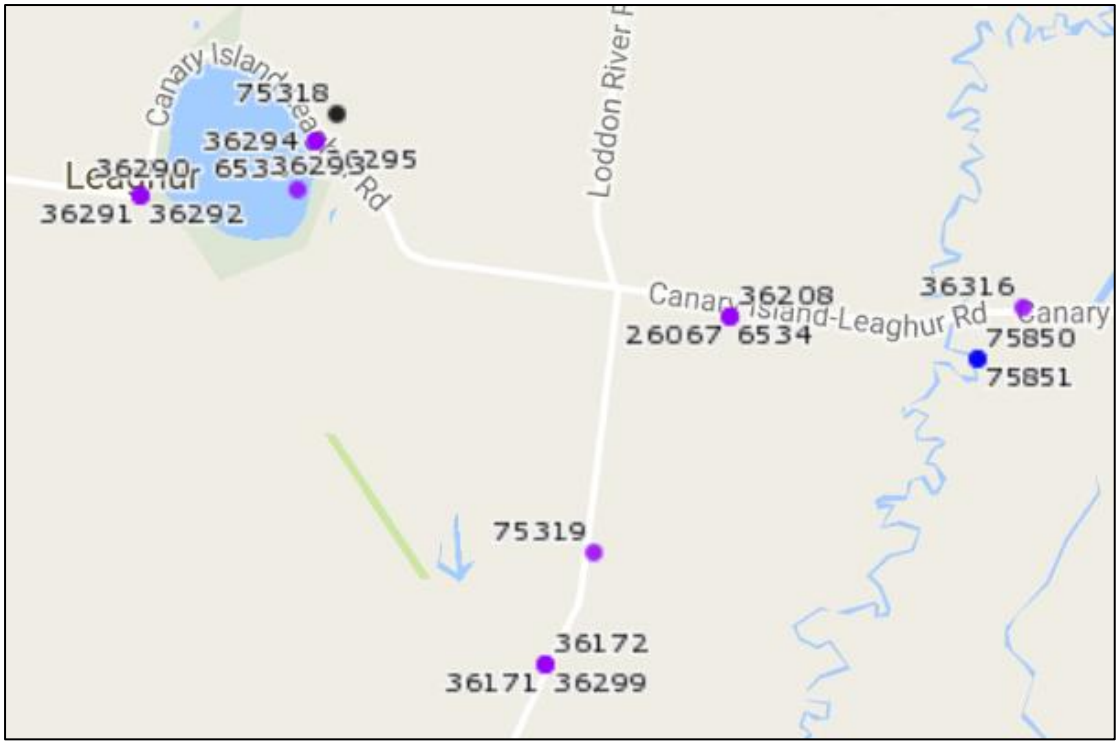


Figure 7. Groundwater bores located near Lake Leaghur (extracted from Victorian Water Information Management System)

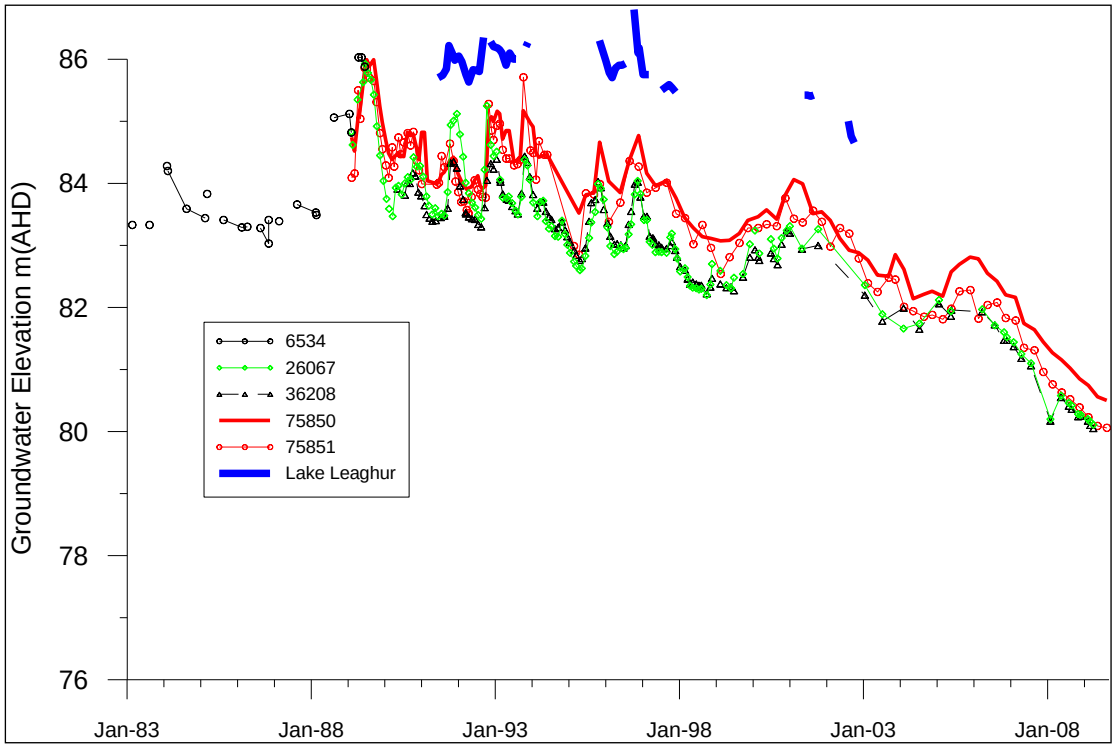


Figure 8. Groundwater level for bores 1 km east of the wetland and Lake Leaghur surface water level (Bartley Consulting 2009)

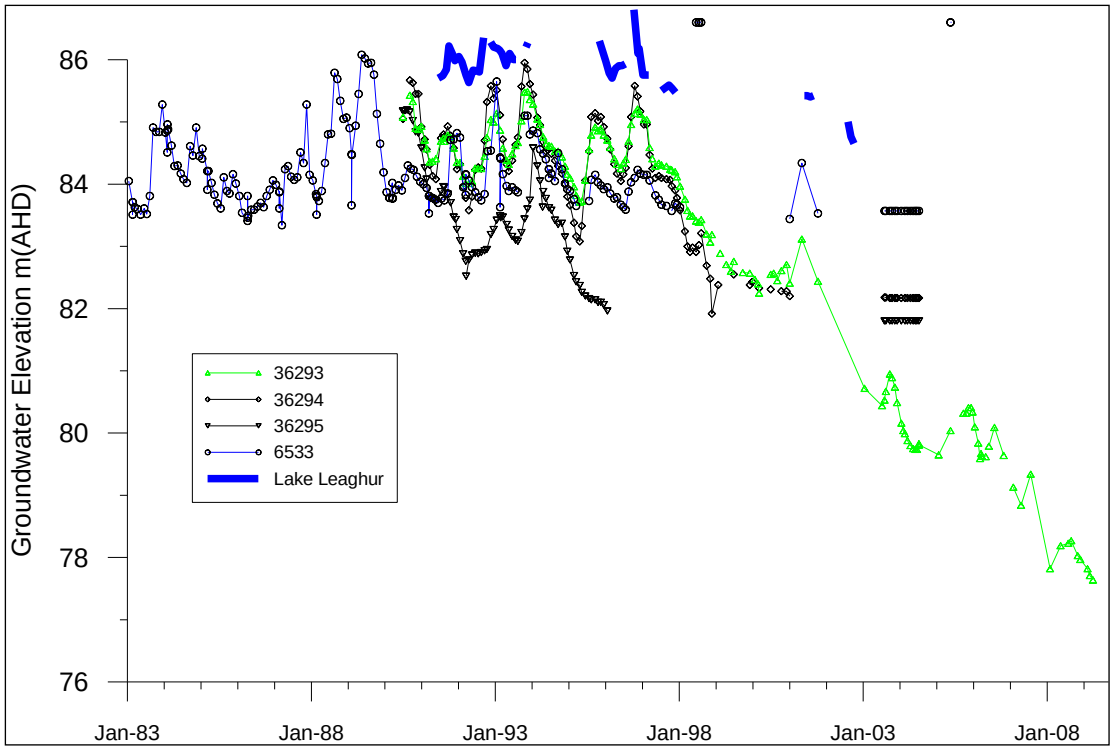


Figure 9. Groundwater level (east) and Lake Leaghur surface water level (Bartley Consulting 2009)

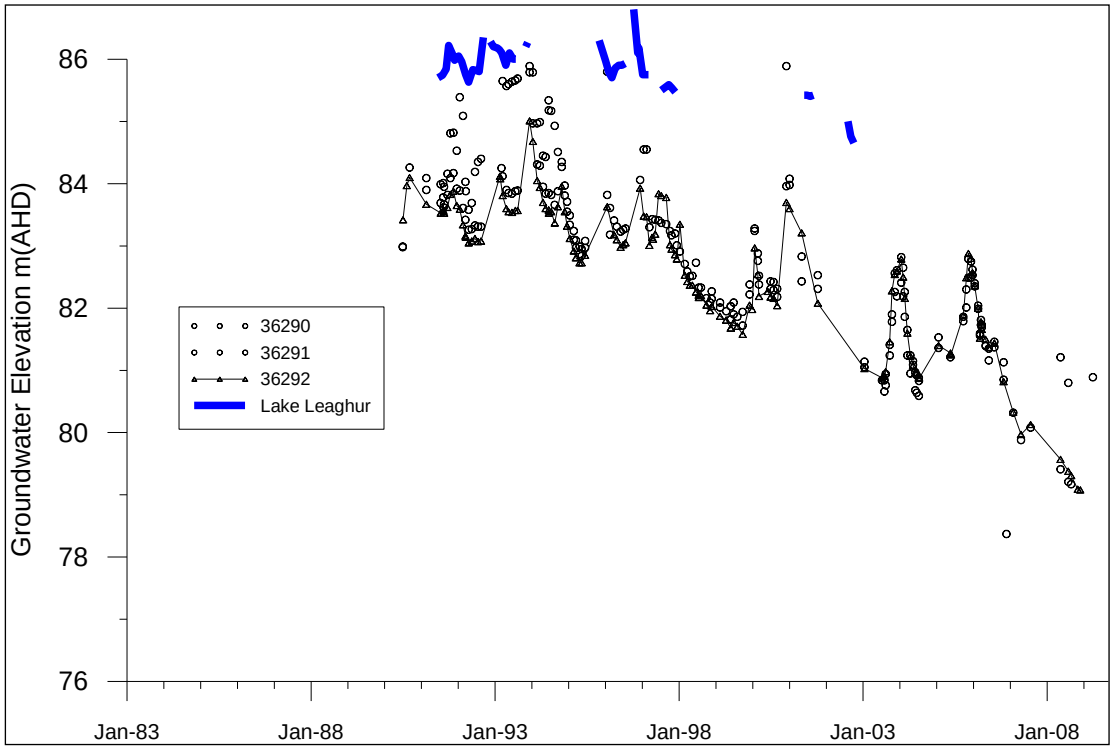


Figure 10. Groundwater level (southwest) and Lake Leaghur surface water level (Bartley Consulting 2009)

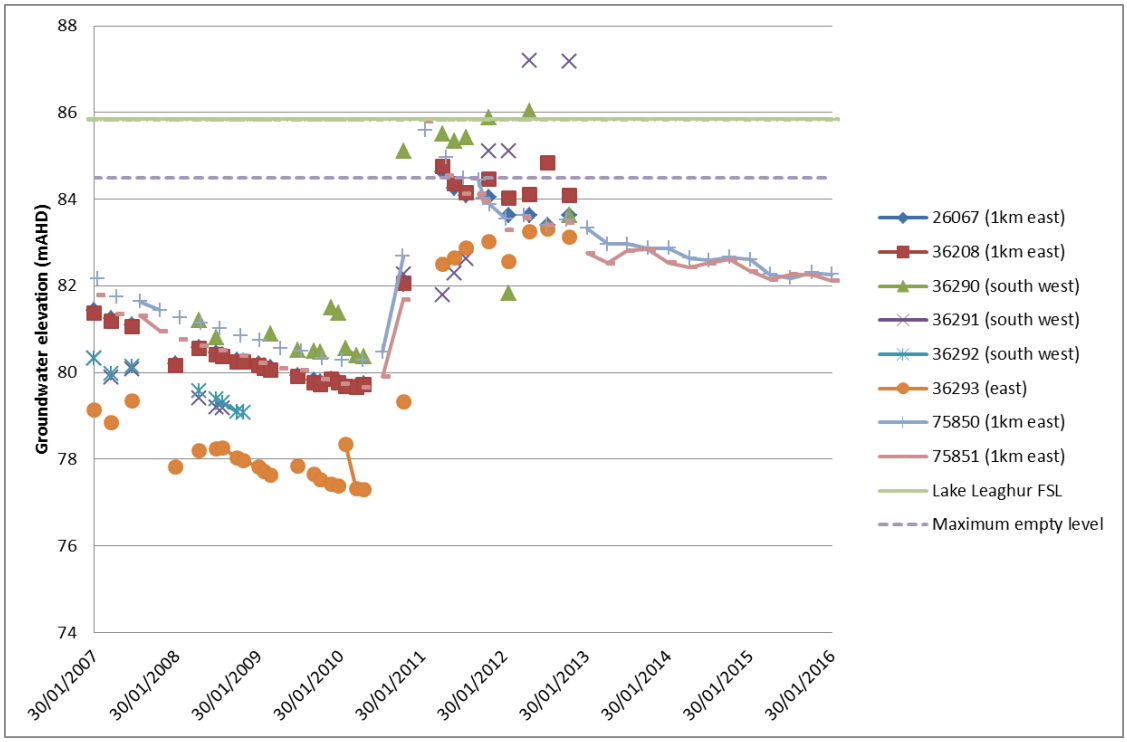


Figure 11. Groundwater level and Lake Leaghur full supply level over the period including the 2010/11, 2012 floods (data from Victorian Water Information Management System)

Data from bores within the vicinity of Lake Leaghur show fluctuating electrical conductivity (EC) levels with mean values ranging from 5,289 µS/cm to 33,681 µS/cm in the northwest. Mean EC levels are lowest at bores adjacent channel no. 2/2. Overall, the bores closer to Lake Leaghur have lower EC levels than in areas further west.

Based on trends in groundwater levels Bartley (2009) concluded:

- Intermittent watering of Lake Leaghur is likely to result in localised groundwater mounding. However, based on the groundwater level being well below the capillary zone (>4m) there is no significant risk of adverse impact on the wetland or neighbouring land through watertable rise.
- Inundating the lake while groundwater levels are low increases the opportunity for salts to move down the profile into the groundwater.
- There would be a small risk of saline groundwater discharge to low-lying areas on neighbouring land if Lake Leaghur was permanently inundated. The risk would increase if regional groundwater levels were to rise (Bartley, 2009).

3.1.4. Water Quality

Water quality data are available for Lake Leaghur for the period of July 1990 to October 2006 (Ecos Environmental Consulting, 2007; Figure 12 EC levels within Lake Leaghur as recorded by DPI between 1990 and 2007

Table 5). Water quality is referenced to the guidelines for riverine floodplain lakes from the Victorian EPA environmental quality guidelines for Victorian Lakes (EPA, 2010; Figure 12 EC levels within Lake Leaghur as recorded by DPI between 1990 and 2007

Table 5). Surface water EC has fluctuated over time, ranging from 600 µS/cm to 6,540 µS/cm, with a median of 1,655 µS/cm (116 readings) (Figure 12). Note that the lake dried out in early 2002. The data suggests that as the water levels decline in Lake Leaghur, salinity increases through evapoconcentration.

Turbidity complies with EPA guidelines most of the time (median 8 NTU; range 1-120 NTU) and is not likely to limit the growth or survival of aquatic biota. Dissolved oxygen levels in Lake Leaghur comply with EPA guidelines most of the time and are generally sufficiently high to support aquatic biota, but vary depending on the water levels (ranging from 9.9% to 198.3%; median 88%). The pH of the lake is variable, complying with EPA guidelines approximately half of the time. The pH is usually alkaline (median 8.4; range 5.6-10.4) and likely within tolerable ranges of the aquatic flora and fauna present at the lake. No nutrient data were available. Overall, water quality at Lake Leaghur is good, and unlikely to limit the establishment or survival of diverse aquatic communities.

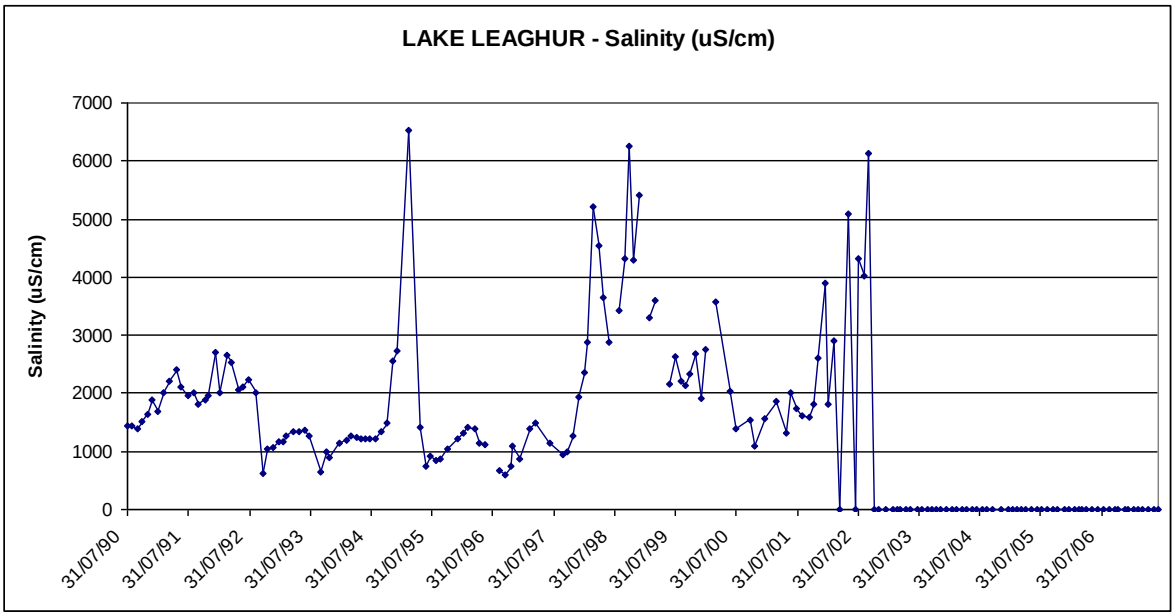


Figure 12 EC levels within Lake Leaghur as recorded by DPI between 1990 and 2007

Table 5. Summary of Lake Leaghur water quality data (1990-2006) (adapted from ECOS, 2007). Shading denotes the compliance of each parameter with EPA guidelines as follows: Red – does not comply most of the time; orange – does not comply some of the time; green – complies all of the time.

	Temperature (degrees C)	pH	EC (µs/cm)	Turbidity (NTU)	DO (% saturation)	Depth (m AHD)
EPA guidelines for floodplain lakes	NA	6.5-8.5	NA	<15 NTU	80-120	NA
Minimum	5	5.6	600	1	9.9	84.5
Maximum	29.8	10.4	6540	120	198.3	86.8
Mean	18.5	8.4	2048	18.6	93.8	85.21

Standard deviation	6.1	0.9	1245	26	36.6	0.74
Median	19.2	8.4	1655	8	88.0	84.88
25th percentile	13.6	7.8	1214	4.1	70.3	84.5
75th percentile	23.3	9.2	2430	20.5	111.7	85.9

3.1.5. Environmental watering

The Northern Victoria Irrigation Renewal Project (NVIRP), now integrated into the GMW Connections Project, sought to upgrade ageing irrigation infrastructure across the Goulburn Murray Irrigation District (GMID) and to save water lost through leakage, seepage, evaporation and system inefficiencies (North Central CMA 2010). It was recognised that some of these 'losses' provided incidental benefits to environmental assets, and Lake Leaghur was classified as a priority wetland that would be heavily impacted by the reduction in channel outfalls associated with increased efficiencies (SKM 2008). To mitigate these impacts, a volume of environmental water was calculated that could be used to sustain the existing ecological character of the wetland (North Central CMA 2010). Additionally, other environmental water has been made available to use at the wetland. The *Environmental Watering Plan* produced in 2010, and updated in 2015, identified the values present at the site and an optimal watering regime was developed to maintain and improve the condition of the wetland.

Table **4** shows the history of environmental watering in Lake Leaghur.

4. Values

4.1. Environmental values

4.1.1. Listings

Lake Leaghur is considered a high value wetland due to the significant vegetation communities, and flora and fauna species (particularly threatened waterbirds) it supports. Table 6 lists the environmental legislation, agreements and conventions that are relevant to Lake Leaghur. Management of the wetland falls within four international listings (JAMBA, CAMBA, ROKAMBA and the Bonn Convention), one national listing (EPBC Act) and two Victorian State listings. A full list of flora and fauna recorded at Lake Leaghur is provided in 0.

Table 6. Environmental legislation, agreements and conventions that relate to Lake Leaghur and/or biota that rely on Lake Leaghur

Legislation, Agreement or Convention	Jurisdiction	Listed
Ramsar Convention on Wetlands	International	×
Japan Australia Migratory Birds Agreement (JAMBA)	International	✓
China Australia Migratory Birds Agreement (CAMBA)	International	✓
Republic of Korea Australia Migratory Birds Agreement (ROKAMBA)	International	✓
Convention on the Conservation of Migratory Species of Wild Animals (Bonn Convention)	International	✓
Environment Protection and Biodiversity Conservation Act 1999 (EPBC Act)	National	✓
Flora and Fauna Guarantee Act 1988 (FFG Act)	State	✓
Victorian advisory lists	State	✓

4.1.2. Water-dependent fauna

Sixty-three water dependent fauna species have been recorded at Lake Leaghur, of which 53 are water bird species. The high productivity, depth and vegetation types (e.g. Red Gum Swamp and Tall Marsh) at Lake Leaghur make it important site for waterbird feeding, roosting and breeding. It has previously provided important breeding habitat for colonially nesting waterbirds (e.g. Little Pied Cormorant, *Phalacrocorax melanoleucos;* Great Egret, *Ardea Alba*) (DCE 1991), and 20 significant waterbird species have been previously recorded at the lake (

Table 7). During drawdown, the wetland supports large numbers of feeding waterbirds (Figure 13).

Figure 13 Waterbirds feeding during the drying phase at Lake Leaghur in 2014

While Freshwater Catfish (*Tandanus tandanus*; protected by the FFG Act) was recorded in the wetland in 1957 (

Table **7**), this species is unlikely to return to the wetland without being translocated. Lake Leaghur has also in the past supported Eastern Long-necked Turtle (*Chelodina longicollis*) and Water Rat (*Hydromys chrysogaster*).

Table 7. Significant water dependent fauna species recorded at Lake Leaghur

Common name	Scientific name	Last record	International status	EPBC status	FFG status	Victorian status
Reptiles						
Eastern Long-necked Turtle	*Chelodina longicollis*	1990				dd
Fish						
Freshwater Catfish	*Tandanus tandanus*	1957			L	en
Waterbirds						
Australasian Shoveler	*Anas rhynchotis*	2013				vu
Blue-billed Duck	*Oxyura australis*	2001			L	en
Caspian Tern	*Hydroprogne caspia*	2011	C,J		L	nt
Clamorous Reed Warbler	*Acrocephalus stentoreus*	2001	B			
Common Greenshank	*Tringa nebularia*	1999	B,C, J,R			vu
Eastern Great Egret	*Ardea modesta*	2001	C, J		L	vu
Freckled Duck	*Stictonetta naevosa*	2001			L	en
Glossy Ibis	*Plegadis falcinellus*	2001	B,C			nt
Hardhead	*Aythya australis*	2013				vu
Intermediate Egret	*Ardea intermedia*	2000			L	en
Little Egret	*Egretta garzetta nigripes*	2001			L	en
Marsh sandpiper	*Tringa stagnatilis*	Unknown	B,C,R			vu
Musk Duck	*Biziura lobata*	2011				vu
Pectoral Sandpiper	*Calidris melanotos*	Unknown	B,J,R			
Red-necked Stint	*Calidris ruficollis*	Unknown	B,C J,R			
Royal Spoonbill	*Platalea regia*	2013				nt
Ruff (Reeve)	*Philomachus pugnax*	Unknown	B,C,J,R			
Sharp tailed sandpiper	*Calidris acuminata*	2011	B,C J,R			
Whiskered Tern	*Chlidonias hybridus javanicus*	2000				nt
White bellied sea eagle	*Haliaeetus leucogaster*	2013	C		L	vu

Key:
International Status: B=BONN, C = CAMBA, J = JAMBA, R = ROKAMBA
EPBC: M = migratory species list, EN = Endangered
FFG Status: L = Listed as threatened, N = Nominated
DELWP Status: e = endangered, vu = vulnerable, nt = near threatened, dd = data deficient
Source: Campbell et al. (2009); DELWP (2015a); DEPI (2013b); Dendini (2015).

4.1.1. Terrestrial fauna

Sixty-one terrestrial bird species (including 11 species with high conservation status) have been recorded from Lake Leaghur. High bird diversity may be attributed to connectivity with remnant terrestrial vegetation in Leaghur State Park. The EPBC listed Striped Legless Lizard (*Delma impar*), and FFG listed Carpet Python (*Morelia spilota metcalfei*) have also been recorded at the lake (Campbell et al. 2009).

4.1.2. Vegetation communities and flora

According to DSEs pre-1750 Ecological Vegetation Class (EVC) mapping, Lake Leaghur was a Red Gum Swamp (EVC 292) surrounded predominantly by Lignum Swampy Woodland (EVC 823) with Semi-arid Woodland (EVC 97) vegetation associated with the lunette to the east, and Riverine Grassy Woodland (EVC 295) at slightly higher elevations on the banks of waterways (DSE 2009f). Recent EVC mapping (DSE 2009g) for Lake Leaghur suggests that the 1750 EVCs still exist; however the extent of Lignum Swampy Woodland, Semi-arid Woodland and Riverine Grassy Woodland is severely diminished.

DSEs 2005 EVC mapping was collected via aerial photograph interpretation, biophysical data and selective ground truthing of sites on a project-by-project basis over a number of years (DSE 2007b). Assessments undertaken by the Murray-Darling Freshwater Research Centre (Campbell et al. 2009) on 22 October 2009 identified that Lake Leaghur is currently characterised by Red Gum Swamp (EVC 292) vegetation. The results of the 2009 field assessment show a marked difference to the DSE EVC maps. The EVC information presented in Campbell *et al.* (2009) is considered more reliable than the DSE 2005 maps and has been used to prepare this EWMP.

Table 8 identifies the conservation status of the observed and mapped EVCs within Lake Leaghur. Refer to Appendix 4 for a detailed map of EVCs observed in October 2009.

Table 8. Conservation status of EVCs at Lake Leaghur

EVC no.	EVC name	Bioregional Conservation Status
292	Red gum swamp	Vulnerable
823	Lignum swampy woodland	Vulnerable
821	Tall marsh	Depleted
97	Semi-arid woodland	Endangered
295	Riverine grassy woodland	Vulnerable
Source: DEPI (2014d); Campbell et al. (2009)		

Native and threatened flora

There have been 81 native flora species recorded at Lake Leaghur, of which 43 are considered water dependant. The different habitats at the wetland including steeper wetland margins containing River Red Gums, inlet channel, open water, and mudflat areas during drawdown support a diverse flora assemblage. Five of the water dependant species are listed as vulnerable, rare or threatened (

Table 9 and Appendix 3) (SKM 2001; DSE 2005). Cane Grass (*Eragrostis australascia*), Ferny Small-flower Buttercup (*Ranunculus pumilio*), Peppercress (*Lepidium pseudohyssopifolium*), Spiny Lignum (*Muehlenbeckia horrida* subsp. Horrida) and Swamp Buttercup (*Ranunculus undosus*) are all identified as either flood-dependant (VEAC 2008) or as wetland/riparian species (DNRE 2002). An

additional six non-water dependant species recorded within Lake Leaghur are protected by the FFG Act as they are from the Asteraceae family (Appendix 3).

Table 9. Listed water dependent flora recorded at Lake Leaghur

Common name	Scientific name	Last Record	FFG Status	DELWP Status
Cane Grass	*Eragrostis australasica*	2009		v
Ferny Small-flower Buttercup	*Ranunculus pumilio*	1993		k
Peppercress	*Lepidium pseudohyssopifolium*	2007		k
Spiny Lignum	*Muehlenbeckia horrida subsp. horrida*	Unknown		r
Swamp Buttercup	*Ranunculus undosus*	1993		v
DELWP listing: r- rare, v – vulnerable, k – poorly known and suspected, but not definitely known, to belong to one of the categories (x, e, v or r) within Victoria (DELWP 2013).				

4.1.3. Wetland depletion and rarity

Both the Corrick and Norman and the updated ANAE classifications have been included in Table 10, which highlights the extent of wetland alteration since European settlement.

Deep Freshwater Marsh (Corrick and Norman Classification)

Lake Leaghur is classified as a permanent open freshwater wetland supporting shallow water (<5m), dead timber, reeds and River Red Gum vegetation (DSE 2009b). However, it is more appropriately described as a Deep Freshwater Marsh (pers. comm. Rob O'Brien [DPI], 8 February 2010). Wetlands supporting healthy and intact River Red Gum Swamp (EVC 292) vegetation are uncommon throughout the area and it is important to maintain them.

Many Deep Freshwater Marshes have been drained for agricultural use such as grazing or cropping, and this wetland type has subsequently decreased in extent across the landscape. The area of deep freshwater marshes across Victoria is estimated to have decreased by approximately 70% since European settlement (DNRE 1997).

Temporary Freshwater Lakes (Victorian Wetland Classification)

Under the updated classification, Lake Leaghur occupies <1% of Temporary Freshwater Lakes in Victoria and the North Central Catchment, however, it represents approximately 6.1 % of the area of Temporary Freshwater Lakes in the Loddon catchment (Error! Not a valid bookmark self-reference.).

Table 10. Area, depletion and rarity of wetland classifications in the region

Region	Corrick and Norman classification Deep Freshwater Marsh				Current classification Temporary Freshwater Lake	
	Pre-European area (ha)	Current area (ha)	Reduction (%)	Lake Leaghur contribution to current area (%)	Current area (ha)	Lake Leaghur contribution to current area (%)
Victoria	176044	54,360	69%	0.1	58,300	0.1
North Central catchment	10,525	4,880	54%	1.2	13,513	0.4
Loddon catchment	8,361	3,753	55%	1.6	966	6.1
Victorian Riverina	17,623	6,910	61%	0.9	3571	1.7

4.1.4. Ecosystem function

'Ecosystem function' is a term used to describe the biological, geochemical and physical processes and components that occur within an ecosystem. These functions relate to the structural components of an ecosystem (e.g. vegetation, water, soil, atmosphere and biota) and how they interact with each other, both at a local (i.e. site specific) and regional (i.e. complex) scale. They include processes that are essential for maintaining life such as storage, transport and nutrient cycling as well as providing resources that support biodiversity such as habitat, food and shelter.

From a landscape context, Lake Leaghur is considered of high value as it represents a depleted wetland type, and supports threatened flora and fauna species and communities that are important for maintaining biological diversity in the biogeographic region. The wetland is particularly important for breeding waterbirds and some migratory species listed under international conventions and bilateral agreements. These values contribute to the overall environmental significance of the Boort district wetlands and the North Central CMA region as a whole.

Table 11 describes the ecosystem functions provided by Lake Leaghur from a local and regional perspective.

Table 11. Ecosystem function of Lake Leaghur from a local and regional scale

Local ecosystem functions	Regional ecosystem functions
• **Convert matter to energy for uptake by biota** - substrate surfaces within the wetland (e.g. woody debris) provide an area for primary producers such as biofilms and plant matter to grow on. These in turn provide food and energy for zooplankton and macroinvertebrates for higher order consumers. • **Provide shade and shelter for biota** - this includes amelioration of extremes in temperature, sunlight exposure and wind as well as protection from predators. The interrelationship of tree, shrub, forb and grass species with compatible geology, soil type, slope aspect, elevation, moisture availability and temperature range characteristics are the main ecosystem components supporting this function. • **Provision of water for consumption** - retention and storage of water for use by biota to enhance growth and development and to ensure survival and reproduction. • **Reproduction** - recruitment of new individuals requires sufficient shelter from predators, food for growth, resources for nest building and cues for breeding (i.e. water level changes, temperature, rainfall etc.). Adequate resources to support newly fledged individuals are also required, including shelter, food and provision of water for consumption. Plants also require specific germination and growth conditions (including flood cues, follow up flooding, drying etc.) to ensure successful recruitment.	• **Movement/ dispersal** - movement of individuals is linked to food web functions (see local ecosystem functions) and is a requirement for the life cycle of some species (i.e. migration). It is also assists with maintaining genetic diversity within the landscape and reduces the risk of local species extinction. The movement of mobile species through the landscape further supports the dispersal of seeds/progapules in the landscape providing a source for colonisation. • **Cycle nutrients and store carbon** - important for essential ecological processes. • **Population persistance** - a number of species require specific habitat to breed. • **Biological diversity** - the provision of a sufficient number and range of habitat types in the landscape supports a diversity of native species. This in turn assists to safe guard the region from the impacts of local catastrophic events (i.e. loss of habitat through fire and clearing) due to there being sufficient alternative habitats available. This supports the maintenance of genetic and species diversity in the region.
Note: The above ecosystem services are particularly important for species with low or restricted mobility.	

4.2. Social values

4.2.1. Cultural heritage

Traditional Owners of the land that encompasses Lake Leaghur include the Wamba Wamba, Barapa Barapa and Wadi Wadi Peoples Native Title Claimants (VC00/5). There are no Registered Aboriginal Parties (RAPs) in the Lake Leaghur area.

Cultural heritage values are abundant on productive wetlands throughout the district, including Lake Leaghur (pers. comm. Rob O'Brien [DPI], 8 February 2010). Seven sites of Aboriginal archaeological significance have been recorded and registered with Aboriginal Affairs Victoria (AAV). These include one hearth, one scar tree, two artefact scatters, and three mounds. Further information can be obtained from AAV.

4.2.2. Recreation

Lake Leaghur is a valuable recreational wetland in the Boort district wetlands area. The lake has historically been a popular location for water skiing (Ecos Environmental Consulting 2007), camping, picnicking, fishing and hunting (DCFL 1989).

4.3. Economic

While Lake Leaghur provides no direct economic value, it provides a number of indirect economic functions such as flood protection, providing refuge for rare and threatened species, trapping sediments, assimilating and recycling nutrients and providing hydrological stability between surface and groundwater in catchments (Gillespie Economics 2008 cited in VEAC 2008)

4.4. Conceptualisation of the site

The habitat types within Lake Leaghur to be targeted by environmental watering are shown conceptually in Figure 14. These habitats include the fringing River Red Gum Swamp (EVC 292); a small population of Cane Grass located at the south of the wetland, the aquatic and amphibious plant community within the lake and associated endemic vegetation that colonize exposed banks and lake bed during the dry phase.

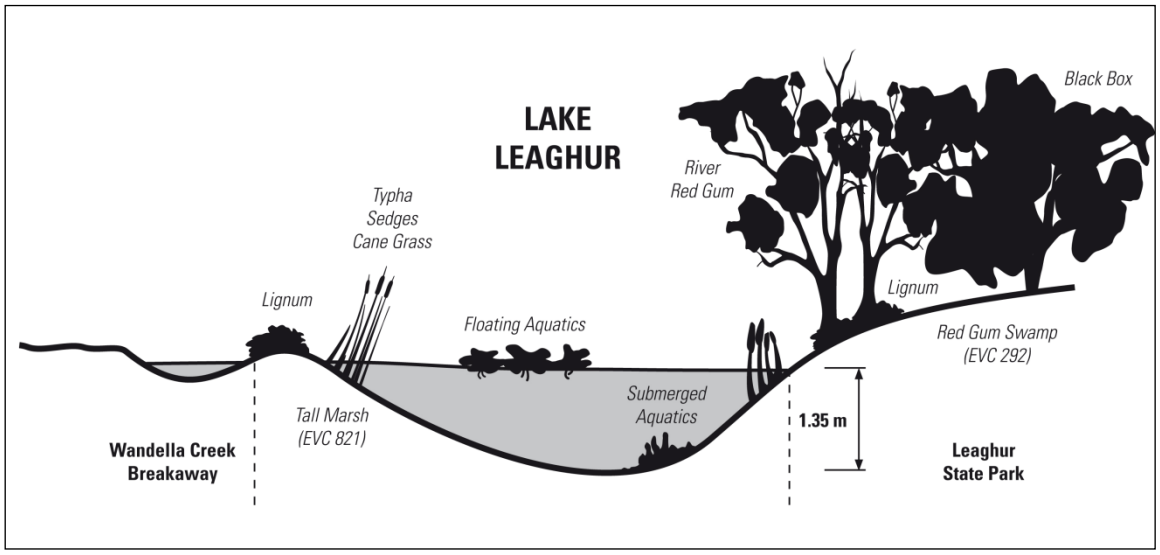


Figure 14.Schematic of wetland areas to be targeted (not to scale)

4.5. Significance

Lake Leaghur satisfies three of the five Murray-Darling Basin Plan criteria for identifying an environmental asset (Appendix 6). The lake is considered a high value wetland due mainly to the significant vegetation communities, flora and fauna species it supports, particularly threatened water birds. In addition, when inundated the wetland is known to support a high diversity and abundance of flora and fauna species.

Lake Leaghur is distinctive as a result of its connectivity to the Loddon River; this is significant as it can receive natural floodwater containing native plant propagules and carbon rich water. Other wetlands within the area are completely disconnected from the floodplain (such as Little Lake Meran situated approximately 9 km north of Lake Leaghur). Lake Leaghur remains connected to the Loddon River and has the ability to receive flood flows via a Wandella Creek breakaway under wet conditions.

5. Ecological condition and threats

5.1. Context

Long-term hydrological changes to Lake Leaghur over the last 150 years (see Section 3.1.2) have altered the wetland substantially, to the detriment of some flora and fauna species and the benefit of others. The current condition has also been impacted by the extreme climatic events of the Millennium Drought (1995-2009) and the large floods that occurred in January 2011.

Displacement of wetland vegetation communities

Many of the pre-European wetland EVCs have been displaced as a result of the altered hydrological regime. Prior to European settlement, Lake Leaghur was a Deep Freshwater Marsh dominated by large River Red Gums (*Eucalyptus camaldulensis*) scattered across the wetland floor (DSE 2009a; pers. comm. Rob O'Brien [NVIRP], 8 February 2010). The diversion of water and raising of the outlet in the 1840s resulted in the death of River Red Gums across the wetland bed. Dead timber was removed in the 1950s to allow water-skiing in the wetland (Ecos environmental consulting, 2007). Lake Leaghur is now only fringed by the species, regenerating around the margins owing to higher, and more permanent, water levels. Historically, a Black Box wetland community was also likely present in the wetland but anecdotal evidence suggests that Black Box has been absent for 150 years because of the construction of the road sill, which led to more permanent water (Ecos environmental consulting, 2007).

Field mapping from an assessment conducted in October 2009 characterised the lake as a cleared wetland surrounded by a narrow fringe of mature River Red Gums (Campbell et al. 2009). Saplings had recruited inside a ring of mature trees. The base of the wetland was dominated by annual grasses and Prickly Lettuce (*Lactuca serriola*). Patches of live Cumbungi existed near the outfall location and were scattered across the wetland. Extensive beds of dead Cumbungi reflect a much greater distribution when Lake Leaghur was inundated. A patch of Tangled Lignum (*Muehlenbeckia florulenta*) existed near the delivery channel in the southwest; however the species was largely confined to scattered individual plants close to and among the fringing River Red Gums.

Moderate to high threat weeds have been observed within Lake Leaghur including: Spear Thistle (*Cirsium vulgare*), Pampas Grass (*Cortaderis sp.),* Sharp Rush (*Juncus acutus ssp. acutus*), African Boxthorn (*Lycium ferocissimum*), Horehound (*Marrubium vulgare*), Poppy (*Papaver sp.*), Weld (*Reseda luteola*), Variegated Thistle (*Silybum marianum*) and Tamarisk (*Tamarix ramosissima*). Approximately 40% of the flora species observed at the lake are introduced.

Index of Wetland Condition

No index of wetland condition (IWC) assessment has been undertaken at Lake Leaghur.

Tree condition

The most recent condition assessment at Lake Leaghur (Campbell et al. 2009) reported that the mature River Red Gum trees were only in moderate health, due to the prevailing drought conditions.

Changes to fauna species diversity and composition

Bird surveys undertaken by DELWP after the Millennium Drought and 2010/11 floods have demonstrated that Lake Leaghur is still capable of supporting bird species in the thousands. In 2014 the lake supported over 2,197 individuals. An average of 480 water birds and 11 species were recorded during monthly water bird surveys over spring and summer during the last wet phase of the lake (2010-2014). Nine threatened water bird species were observed during these surveys. Prior to the Millennium Drought when Lake Leaghur had a near permanent regime, it also supported good

fish populations (pers. comm. Rob O'Brien [NVIRP], 8 February 2010); although clearly, the dry conditions over the last decade mean this would no longer be the case.

5.2. Condition trajectory – do nothing

As a complementary action to the RCS, the North Central CMA developed the *North Central Climate Change Adaptation and Mitigation Plan* (North Central CMA 2015b), which predicts the long term impacts of climate change under a range of scenarios. Although the scale of impacts (e.g. severity, timeframe) differs for each scenario, the following impacts are expected to occur across all scenarios:

- Increased average temperatures in all seasons
- More hot days and less very cold days
- Decrease in winter rainfall
- Possible increase in summer rainfall
- Increase intensity of extreme rainfall
- Continued rainfall variability
- Increased frequency and severity of bushfire and flood events.

Under these predictions, Lake Leaghur is likely to experience less natural rainfall over the winter period, higher spring and summer temperatures and increased evaporation during summer.

Although significantly altered from its pre-European state, the acquired vegetation values of the wetland are considered to be in reasonably good health, having recovered from the Millennium Drought and the 2010-11 floods. The wetland supports a high diversity of water birds that feed and breed there during wet phases, including threatened and migratory species.

In the absence of environmental water, these water-dependent values will diminish. This will be further exacerbated by drier climatic scenarios. There would be a significant loss of diverse habitat and refuge for water birds and other wetland fauna species, reducing opportunities for breeding and recruitment in the landscape. Macrophyte seedbanks and invertebrate egg banks may become unviable. Large River Red Gums would likely decline in health or die; there would be little recruitment of River Red Gums; and populations of other significant wetland flora species such as Cane Grass could diminish or be lost from the lake.

6. Management objectives

6.1. Management goal

The long term management goal takes into account the values the wetland supports, the current wetland condition and potential risks that need to be managed. The goal is the same as that previously developed for the *Lake Leaghur Environmental Watering Plan 2015*.

Lake Leaghur Long-term Management Goal: To provide a water regime that supports flora and fauna that are typical of a Deep Freshwater Marsh, in particular providing key waterbird habitat (breeding and nesting) within a Red Gum Swamp (EVC 292).

6.2. Ecological objectives

Ecological objectives describe the intended outcomes of environmental water delivery. They contribute towards achieving the long term management goal. The ecological objectives for Lake Leaghur are based on the key water-dependent values of the wetland. Where appropriate, these are expressed as the target condition or function for each key value, using one of the following trajectories:

- restore – recover a value that has been damaged, degraded or destroyed and return it to its original condition.
- rehabilitate – repair a value that has been damaged, degraded or destroyed but not to the extent of its original condition.
- maintain – maintain the current condition of a value.

Ecological objectives largely reflect those outlined in the EWP and are presented as primary objectives and as secondary objectives. Primary objectives are related to the key values of Lake Leaghur. Secondary objectives either support the primary objectives (e.g. macroinvertebrates are a food source for fish) or are objectives for values with little baseline information (e.g. frogs). If the monitoring budget in future years is restricted, the North Central CMA will prioritise monitoring of primary objectives.

The ecological objectives for Lake Leaghur and the justification for each are shown in Table 12.

Table 12. Ecological objectives and their justifications for Lake Leaghur

Objective	Justification
1. Primary Objective – species	
1.1 Maintain the health and restore the distribution of River Red Gum vegetation (EVC 292) • Maintain health of existing trees • Provide opportunities for recruitment across the wetland bed	As well as being valuable in their own right, River Red Gum trees provide hollows, fallen branches and shading for habitat, and provide a source of seed for recruitment
1.2 Restore Cane Grass populations	Listed as a vulnerable species in Victoria and was likely widespread throughout Lake Leaghur. Also a key habitat for breeding waterbirds and macroinvertebrate productivity. Only a very small population is now evident to the south of the wetland.
1.3 Establish breeding opportunities for waterbirds, frogs: e.g. Little Pied Cormorants, Ducks, Great Egret[1], Spotted Marsh Frog.	Linked to habitat objectives. Providing various habitat types and highly productive invertebrate and plant communities through a wetting and drying cycle should promote breeding opportunities for other fauna.
2. Secondary Objectives – habitat	
2.1 Restore diverse aquatic and amphibious plant communities in the wet phase and endemic plant communities associated with exposed lake bed and banks during the dry phase.	Aquatic and amphibious plants provide habitat and food sources for birds (e.g. Hardhead, Musk Duck), frogs and invertebrates.
3. Secondary objectives – process	
3.2 Ensure adequate biomass of macroinvertebrate functional feeding groups and zooplankton to support ecological processes and wetland foodwebs.	Macroinvertebrates and zooplankton are critical components of wetland foodwebs. Productive macroinvertebrate and zooplankton communities provide food that will support large numbers of frogs, waterbirds and turtles. Sustaining multiple functional feeding groups is important because they use different habitats and serve different ecological processes.

6.3. Hydrological requirements

Hydrological requirements based on the ecological objectives detailed in Section 6.2 have been developed for Lake Leaghur. Table 13Table 13 summarises this information.

[1] Known to breed in Leaghur State Park (Parks Victoria 1998)

Table 13. Hydrological requirements for Lake Leaghur

Ecological Objectives	Water management area	Hydrological Objectives										
		Recommended number of events in 10 years			Inter-drying period duration (months)			Duration of ponding (months)			Preferred timing of inflows	Depth (m)*
		Min	Opt	Max	Min	Opt	Max	Min	Opt	Max		
1. Primary objectives												
1.1 Maintain the health and restore the distribution of River Red Gum vegetation (EVC 292) • Maintain health of existing trees • Provide opportunities for recruitment across the wetland bed	Fringe/Bed	2	3-6	7	6	18-30	54	2	3-6	18	Spring/Summer	Not critical for existing trees, variable to avoid fringe effect and promote germination across different elevations
1.2 Restore of Cane Grass populations	Fringe	1.4-2	3-4	5	2	6-18	60-84	1	1-6	6	Not critical	0.1-0.5 m
3.1 Establish breeding opportunities for waterbirds and frogs: e.g. Little Pied Cormorants, Ducks, Great Egret, Spotted Marsh Frog.	Fringe/Bed	Variable depending on species						4	5-10 (extend as required if waterbird breeding occurs)	Until fledged	Spring, provide top-ups to extend waterbird breeding season if required	Variable, but >0.2 m
2. Secondary objectives – habitat												
2.1 Restore diverse aquatic and amphibious plant communities in the wet phase and endemic plant communities associated with exposed lake bed and banks during the dry phase	Fringe/Bed	2	3-6	7	-	-	36	4	4-9	-	Spring	>0.3 m
3. **Secondary objectives – processes**												
3.1 Ensure adequate biomass of	Whole	Duration should be variable and seasonally dependent, and inundation should be maintained for at least 3 – 6 months to ensure suitable habitat										

Ecological Objectives	Water management area	Hydrological Objectives										
		Recommended number of events in 10 years			Inter-drying period duration (months)			Duration of ponding (months)			Preferred timing of inflows	Depth (m)*
		Min	Opt	Max	Min	Opt	Max	Min	Opt	Max		
macroinvertebrate functional feeding groups and zooplankton to support ecological processes and wetland foodwebs	lake	long enough to complete life cycles. A drying phase for at least two months, occurring once in three years will promote microbial decomposition of organic matter.										
Source: Campbell et al. 2009; Fitzsimons et al. 2011, Roberts and Marston 2011, Rogers and Ralph 2011												

6.4. Watering regime

The recommended wetland watering regime for Lake Leaghur has been derived from the ecological objectives and hydrological requirements detailed in Section 6.2 and 6.3, and considers the range of needs and tolerances of characteristic species in each objective. To allow for adaptive and integrated management, the watering regime is framed using the seasonally adaptive approach. This means that a watering regime is identified for optimal conditions, as well as the maximum and minimum tolerable watering scenarios. The minimum watering regime is likely to be provided in drought or dry years, the optimum watering regime in average conditions and the maximum watering regime in wet or flood years when there may be a need to use the lake to store floodwater.

The optimal, minimum and maximum watering regimes are described below. Due to the inter-annual variability of these estimates (particularly the climatic conditions), the volume of water needed for any given year will need to be determined by the environmental water manager when watering is planned. Note that there are likely to be restrictions on the timing of water delivery depending on changes to delivery arrangements (see section 8.1). Under the most likely arrangement (use of the existing, now private Channel 2/2), environmental water can be delivered to Lake Leaghur at a rate of 50 ML/day for four weeks prior to, and four weeks after the irrigation season in any given year. There is capacity to deliver a minimum of 14 ML/day of environmental water to Lake Leaghur during the irrigation season with three day notice period required to GMW. This coincides with the critical timing to provide top up flows in response to a colonial water bird breeding event.

Minimum watering regime

Fringe and wetland target years (2 events in 10 years): Fill to FSL (1.35 m at 85.85 m AHD) in winter/spring to inundate River Red Gum Swamp (EVC 292) one in five years. The wetland should not be allowed to remain dry for more than 3 consecutive years. Provide top-ups (where necessary) to extend the duration of inundation to a minimum of four months if waterbird breeding is observed.

Ensure water inundates Cane Grass for 1-6 months during each event and allow natural draw-down over 18 months.

Optimum watering regime

Fringe and wetland target years (3-4 events in 10 years): Fill to FSL (1.35 m at 85.85 m AHD) in winter/spring to inundate River Red Gum Swamp (EVC 292) twice in 10 years, and to 84.75m AHD once in 10 years and to 84.85m AHD once in 10 years. This will enable variability in depth (flood extent) to facilitate germination of River Red Gum seedlings across a range of elevations. The aim is to establish a multi-age classed population across a wide wetland fringe zone. Provide top-ups (where necessary) to extend the duration of inundation to seven to ten months if waterbird breeding is observed.

Ensure water inundates Cane Grass for 1-6 months during each event and allow natural draw-down.

Maximum watering regime

Fringe and wetland target years (5 events in 10 years): Fill to FSL (1.35 m at 85.85 m AHD) in late winter/early spring to inundate River Red Gum Swamp (EVC 292) no more than one in two years and allow natural draw-down. Where possible, enable variability in depth (flood extent) to facilitate germination of River Red Gum seedlings across the wetland. Provide top-ups (where necessary) to extend the duration of inundation to seven to ten months if waterbird breeding is observed.

Ensure water inundates Cane Grass for 1-6 months during each event and allow natural draw-down.

7. Risk Assessment

A qualitative risk assessment has been undertaken for Lake Leaghur to assign the level of long-term risk associated with:

- delivery of environmental water; and
- achieving set ecological objectives (i.e. factors outside delivery of environmental water inhibiting ability to achieve objective)

As shown in Table 14, the relationship between likelihood (probability of occurrence) and the severity (severity of the impact) provide the basis for evaluating the level of risk.

Table 14. Risk Matrix

		Severity		
		Major	Moderate	Minor
Likelihood	Probable	High	High	Moderate
	Possible	High	Moderate	Low
	Improbable	Moderate	Low	Low

The results from the Lake Leaghur risk assessment are presented in Table 15, adapted from the *Lake Leaghur Environmental Watering Plan 2015*. Management measures relevant for the moderate to high level risks are recommended and the residual risk is then recalculated using the same risk matrix. Please note that short-term operational risks (e.g. environmental releases causes flooding of private land) are assessed as part of the development of the *Seasonal Watering Proposal for the Loddon River System* which includes Lake Leaghur.

Table 15. Possible risks and mitigation measures associated with environmental water delivery to Lake Leaghur

Risk No.	Threat	Outcome	Relevant objective	Likelihood	Severity	Risk rating	Management Measure	Residual Risk rating
1	**Threats from environmental water**							
1.1	Groundwater intrusion or discharge to low-lying surrounding area resulting from elevated groundwater levels[2]	• Poor vegetation health; limited regeneration of wetland plants; dominance of salt tolerant species; and unsuitable habitat for waterbirds and habitat for food sources in discharge areas.	All	Improbable	Moderate	Low	• Monitoring of groundwater levels and salinity within wetland and surrounding area to evaluate the threat. • Adaptive management of water regime to minimise impacts on groundwater levels (i.e. reduce flooding frequency).	Low
1.2	Recommended water regime is inappropriate for ecological objectives	• Decline or loss of River Red Gum and Cane Grass. Decline in regional waterbird abundance or diversity.	All	Improbable	Major	Moderate	• Seasonal water delivery, regular monitoring and adaptive management of watering regime. • Review recommendations in light of emerging information on the requirements and status of key species occurring at the lake (e.g. Cane Grass).	Low
1.3	Poor water quality (i.e. temperature fluctuations, blackwater events, high turbidity, Blue-Green Algae, high salinity levels)	• Reduced primary production (turbid water), limiting food resources for aquatic invertebrates and waterbirds. • Encroachment of vegetation that thrives under saline conditions. • Excessive algal growth • Potential fish kills	All	Possible	Moderate	Moderate	• Monitor quality of source water used to deliver environmental flows and delay or defer delivery if quality is poor. • Monitor groundwater levels, salinity and nutrient inputs in conjunction with a regular water quality monitoring program. • Adaptively manage water regime and delivery. Environmental water could be used to provide 'freshening' flows.	Low
2	**Threats to achieving ecological objectives**							

[2] Under current conditions of low groundwater levels, this is unlikely. There would be a small risk of saline groundwater discharge to low-lying areas on neighbouring land if Lake Leaghur was permanently inundated. The risk would increase if regional groundwater levels were to rise (Bartley Consulting 2009).

Risk No.	Threat	Outcome	Relevant objective	Likelihood	Severity	Risk rating	Management Measure	Residual Risk rating
2.1	Limited water availability (i.e. insufficient environmental water allocation to provide the desired water regime)	• Failure to achieve identified objectives and overall water management goal. Decline or loss of River Red Gum, Cane Grass, and aquatic, amphibious and dry phase plant communities. Decline in regional waterbird abundance or diversity.	All	Possible	Major	High	• Ensure sufficient information is collected for prioritisation in environmental allocation processes. • Re-model volumes required in light of changing climatic conditions and wetland phase • Consider using mitigation water to provide small pulse flows to maintain aquatic refuge for EVC 821(Tall Marsh) and aquatic and amphibious plants that have previously persisted at the channel outfall in times where the optimal regime is limited by water availability.	Moderate
2.2	Encroachment or dominance of Cumbungi, Common Reed or weeds	• Monoculture of Typha sp. and Phragmites sp. • Spread of waterlogging or salt tolerant weeds such as Sharp Rush or African boxthorn • Loss in species diversity • Habitat loss (i.e. open water) • Watering events prove unproductive for waterbirds	1.1, 1.2, 2.2, 2.3, 2.4	Probable	Major	High	• Active management (spraying, slashing, crash grazing etc.) to remove dominant plants • Regular monitoring and adaptive management of water regime to minimise the persistent summer inundation that supports Typha and Phragmites. • Adaptive management of water regime to minimise impacts on groundwater levels (i.e. reduce flooding frequency) if salt/waterlogging weeds become dominant.	Moderate
2.3	Introduced species – fish	• European Carp and Gambusia are likely to be present in the irrigation system and therefore, populations may establish in Lake Leaghur after watering. A high abundance of these species may limit the growth of aquatic plants, predate on frogs (food sources for waterbirds) and reduce water quality. However they may also provide a source of food for piscivorous waterbirds.	11.1, 1.2, 2.2, 2.3, 2.4	Possible	Moderate	Moderate	• Drying as recommended in the regime will manage pest fish populations. • Investigate options to prevent Carp access to wetland during fill events (e.g. carp screen). • A broad scale method for carp control is identified as a knowledge gap across the entire Murray-Darling Basin.	Low

Risk No.	Threat	Outcome	Relevant objective	Likelihood	Severity	Risk rating	Management Measure	Residual Risk rating
2.4	Introduced species – foxes	• Foxes have been observed at Lake Leaghur. Impacts include predation of juvenile waterbirds, turtles and mammals.	1.2	Probable	Moderate	High	• Fox control program required • Residual risk reduced to reflect water and target fox control management	Moderate
2.5	Seedbank is depauperate and does not support regeneration of a diverse plant community	• Failure to establish endemic aquatic and amphibious vegetation upon inundation, and endemic plant species in the dry phase following watering • Monoculture of T*ypha* sp. and Phragmites sp. • Emergence of unexpected native or exotic species • Restricted regeneration • Lower species diversity	All	Possible	Moderate	Moderate	• Monitoring (e.g. IWC) and adaptive management. • Active planting during watering events to re-establish endemic aquatic/amphibious plant species, or following watering for dry phase for lake bed species.	Low
2.6	Recreational pressures e.g. hunting increases in response to water event	• Loss of both game and non-game species • Damage to vegetation • Loss of woody debris	1.2	Possible	Minor	Low	• Reporting of waterbird monitoring information between relevant bodies including Field and Game Australia and DELWP (particularly the occurrence of listed species prior to opening of the hunting season). • Supervision of hunting by Parks Victoria	Low
2.7	Fire	• Habitat and resource loss (e.g. standing timber) • Water quality may deteriorate.	All	Possible	Major	High	• Monitoring (e.g. tree regeneration) post fire and adaptive management to facilitate rapid recovery if required (e.g. direct seeding or revegetation).	Moderate
2.8	Chytrid fungus	Chytrid fungus is an infectious amphibian disease that impairs osmoregulation of most species. Although there has been no testing for the disease at Lake Leaghur, it is considered widespread in Victoria. Mortality rates of up to 100% are common, with adults more vulnerable than tadpoles.	1.2	Possible	Moderate	Moderate	• Undertake zoospore counts to identify presence of disease- N.B. the disease is not as prevalent in semi-arid regions (vivacity linked to wet and cold conditions). • No change to residual risk due to limited control measures available.	Moderate

8. Environmental water delivery infrastructure

Until the mid 2000s, Lake Leaghur received outfalls and environmental water from channel 2/2 via a short outfall delivery channel (Figure 15). The outfall channel has a capacity of 60 ML/day. The outfall regulating structure is fully automated and also has a capacity of 60 ML/day (Hillemacher and Ivezich 2008).

The outlet is characterised by an overflow sill located to the north of Lake Leaghur. It has an elevation of 85.85 m AHD which determines the storage capacity at FSL of 664 ML (Price Merrett Consulting 2006). From the outlet, water travels north along Stringers Lane, through Leaghur State Park and into Lake Meran via natural inlets (SKM 2001).

At a flow rate of 60 ML/day it would take approximately 11 days to fill Lake Leaghur from empty, assuming that there are no losses and operating at full capacity (Hillemacher and Ivezich 2008).

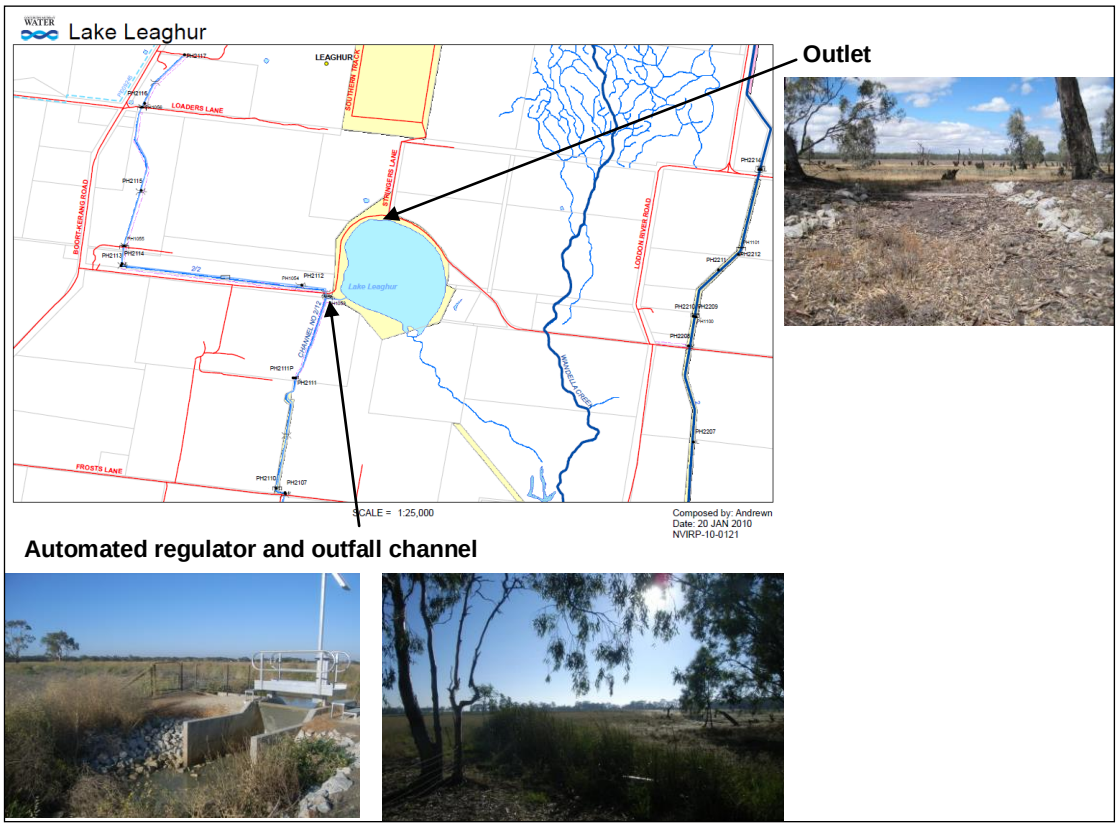


Figure 15. Lake Leaghur Infrastructure

8.1. Proposed changes to existing infrastructure

The GMW Connections Project is a works program to upgrade ageing irrigation infrastructure across the GMID to save water lost through seepage, leakage, evaporation and system inefficiencies. Works will include lining and automating channels, rationalising non-backbone channels, building pipelines and installing new, modern metering technology.

The Lake Leaghur EWP developed in 2010 identified that the GMW Connections Project was investigating the rationalisation of 9 km of Channel 2/2. In 2013, approximately seven kilometres of the Pyramid-Boort No. 2/2 channel was rationalised as part of a water savings package. The 2/2 channel that delivers water to Lake Leaghur is now a private channel and the wetland cannot receive environmental water under this current arrangement.

As per the Water Change Management Framework (WCMF) (GMW 2013, Section 16) the ongoing environmental watering requirements for Lake Leaghur need to be considered as part of the Connections Program. GMW Connections are responsible for "retain(ing) infrastructure and improving where practicable, where it will be required for delivering environmental water…." (GMW 2013).

Options to return the management of environmental water to Lake Leaghur have been investigated by GMW and the North Central CMA. Two options to be able to deliver water to Lake Leaghur are still being investigated by GMW and include (refer to Figure 16):

1) *Constructing a new environmental water channel*
This new option would divert water from Pyramid-Boort No. 2 channel (approximately 2-3 km west of the wetland with capacity of 350 ML/day). The alternative option would cross the Wandella Creek (bore underneath) and outfall into the breakaway that feeds into the wetland to the south (works would occur near the lunette and would have a high impact both environmentally and culturally). The estimated cost for these works is in the order of $1 million.

2) *Use of privately owned 2/2 channel during and outside of the irrigation season with legal agreement formed with the landholder*.
This preferred option is currently being negotiated where

- Environmental water can be delivered to Lake Leaghur at a rate of 50 ML/day for four weeks prior to and four weeks after the irrigation season in any given year
- There is capacity to deliver a minimum of 14 ML/day of environmental water to Lake Leaghur during the irrigation season with three day notice period required to GMW. This coincides with the critical timing to provide top up flows in response to a colonial water bird breeding event.

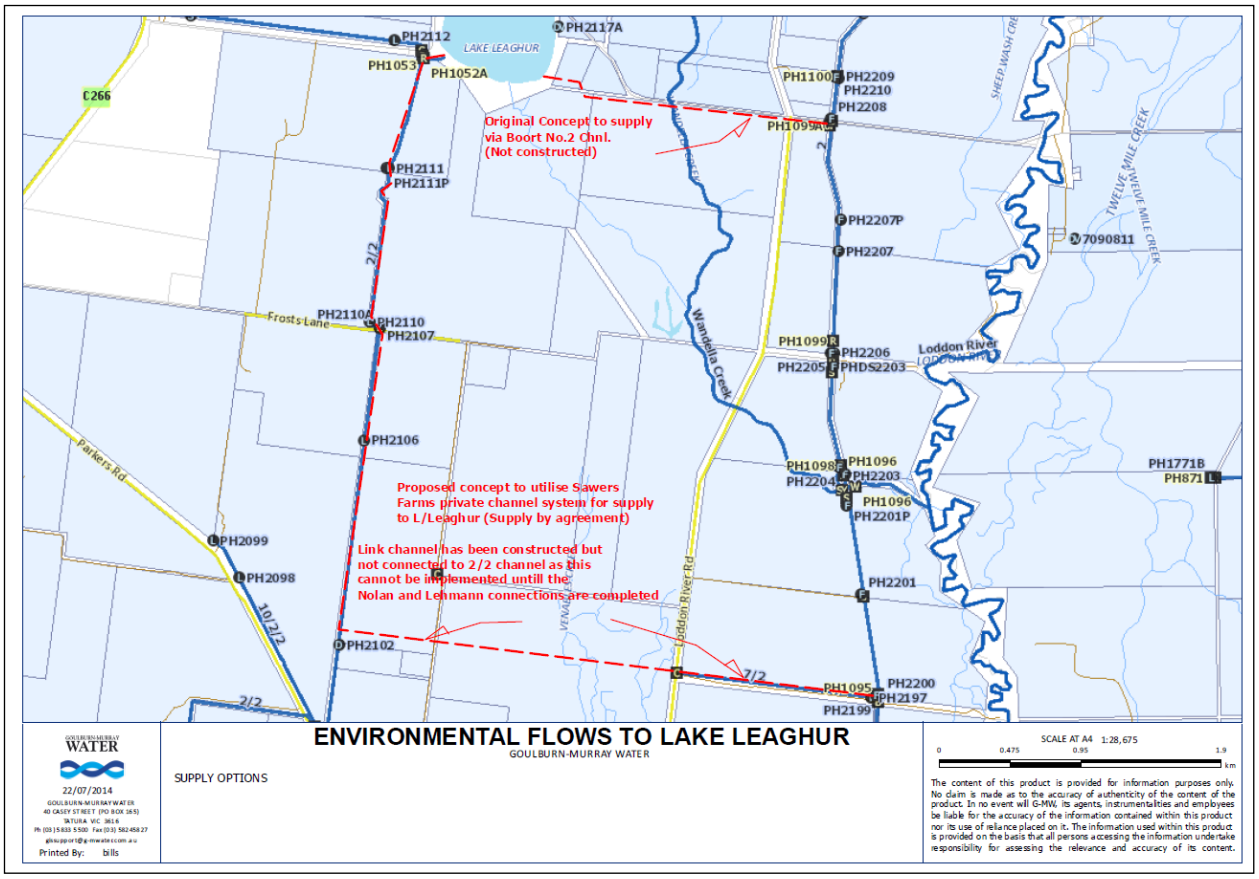


Figure 16. Lake Leaghur potential alternative supply options

8.2. Infrastructure recommendations

European Carp (*Cyprinus carpio*) are abundant within the GMW channel system and there is currently no carp screen between the channel system and Lake Leaghur. Carp can have detrimental impacts on wetlands by increasing the turbidity of the water, preventing the establishment of aquatic vegetation and competing with native species. Large Carp have a much greater impact than small Carp and because Lake Leaghur will regularly dry there is little chance that small carp entering the wetland will have a chance to grow to maturity. Therefore, the main Carp management aim should be to limit the number of large Carp that can enter the wetland.

Installing a Carp screen on the environmental water delivery outlet should prevent larger carp entering the wetland. A screen with a spacing size of 50 mm would minimise blockage while restricting the passage of large Carp (SKM 2005).

The following should be considered prior to installation:

- The screen should be positioned to prevent fish entry.
- It should be designed to rotate about a vertical axis (to clear any accumulated weed or debris).
- It should be easily removed and readily accessible.
- Regular maintenance will be required during regulator operation to prevent blockages.
- Installation will reduce the hydraulic capacity of the regulator (SKM 2005).

Costs for a carp screen range from $5,000 to $20,000 depending on size, functionality and installation requirements.

9. Complementary actions

Implementation of the recommended watering regime will benefit the environmental values of Lake Leaghur. Some objectives require complementary actions in order to be realised. These are directly related to the risk section, i.e. risk of not achieving objectives (Table 16).

Table 16. Complementary actions to enhance the benefits of environmental watering

Activity	Rationale
Typha spp. and *Phragmites australis* management	These two species have benefited from altered hydrology in the wetland and can form large mono-specific stands. This may result in reduced species diversity and loss of important habitat for wetland species (i.e. open water and mudflats). The water regime that promotes *Typha* is flooding or water logging from spring to late summer; this could occur as Active management such as spraying, mowing and slashing, in conjunction with an appropriate watering regime (i.e. drying phase) , will assist in controlling the extent of these species.
Exotic flora control	Forty-three percent of species recorded at Lake Leaghur are exotic. These species have the potential to disturb the function of native vegetation through displacement and competition. Weed control such as manual removal and chemical application should target high threat terrestrial and amphibious weeds. A weed management plan may need to be developed for the lake if the high proportion of weeds persist after several watering events.
Fox control	Foxes are commonly observed at Lake Leaghur. Impacts include predation on juvenile waterbirds, turtles, mammals and terrestrial birds. Fox control measures include baiting and interactive fox drives, and should be intensified during wet phases, particularly if bird breeding occurs.
Replanting with endemic lake bed vegetation species.	The viability of the seedbank at Lake Leaghur is currently unknown. If endemic lake bed vegetation does not develop in the dry phase following the first watering event, replanting with will be required to allow the seedbank to establish in the first few watering events.
Protect the Wandella Creek breakaway	Lake Leaghur is still connected to the Loddon River and is able to receive natural flooding. Protecting the creek from erosion via fencing to exclude livestock, as well as revegetation and weed control would be of benefit.

10. Demonstrating outcomes

Monitoring programs enable water managers to justify the application of environmental water by demonstrating that environmental outcomes are being achieved. Monitoring is undertaken to determine the success of managed watering events, and to inform adaptive management of Lake Leaghur.

Two types of monitoring are recommended to assess the effectiveness of the proposed water regime on objectives and to facilitate adaptive management:

- Intervention monitoring
- Long-term condition monitoring

It is essential that the results of any monitoring program are regularly analysed to detect changes and adjust the management actions if required.

10.1. Intervention monitoring

Intervention monitoring assesses the response of key environmental values to specific watering events (intervention) and indicates whether the action is achieving its intended ecological objectives e.g. to increase the occurrence of waterbird breeding events. Intervention monitoring may measure water quality, vegetation and biota (i.e. native waterbirds).

Current intervention monitoring

The North Central CMA conducts an ongoing environmental flow water resource planning program for Lake Leaghur, which is undertaken as part of the implementation of the Seasonal Watering Proposal. Each year environmental flows are released based on an assessment of the monitoring data as well as the water availability.

The internal CMA monitoring program currently includes waterbird surveys, water quality measurements and short-term changes to wetland condition. This program does not adequately cover the suite of ecological objectives and their response to flows.

Required intervention monitoring

Further intervention monitoring is required so that the CMA is able to adaptively manage Lake Leaghur over the next ten years to ensure that environmental water deliveries are achieving the ecological objectives. The proposed intervention monitoring program and the objective that is being monitored is shown in Table 17.

Table 17. Required intervention and surveillance monitoring for the implementation of the Lake Leaghur EWMP

Ecological objectives		Monitoring question	When	Method
1.1	Restore Cane Grass populations	How has the vegetation distribution changed in response to watering?	In autumn and spring, before and approx. one year after watering event	Photo points Vegetation distribution mapping (e.g. using drones, aerial photography or transect surveys) Transect surveys to record recruitment Tree health assessments via either (1) fisheye photography to quantify canopy density or using remote sensing imagery to measure canopy health (see Cunningham et al 2009) if part of a broader landscape scale assessment of tree condition.
1.3	Maintain the health and restore the distribution of River Red Gum vegetation (EVC 292) • Maintain health of existing trees • Provide opportunities for recruitment across a greater range of elevations	Has RRG health improved as a result of watering? Are juvenile RRGs recruiting across the bed of the lake?	Before watering and approximately one year after Surveys in late spring/early summer	
2.3	Restore diverse aquatic and amphibious plant communities in the wet phase and endemic plant communities associated with exposed lake bed and banks during the dry phase.	Have amphibious plant communities increased in extent and diversity from watering compared with previous events?	Amphibious and aquatic plant surveys in late spring/summer when lake is inundated. Surveys of endemic plant communities associated with exposed lake bed and banks in year after lake has dried.	
1.2	Establish breeding opportunities for waterbirds, frogs and invertebrates: e.g. Little Pied Cormorants, Ducks, Great Egret	Are colonially nesting waterbirds (e.g. Little Pied Cormorant and Great Egret) breeding?	Monthly during spring/summer throughout watering event	Area searches to count the number of nests of each species (Baldwin et al. 2005) and nest searches to determine egg numbers and chick survival.
		Are frogs calling and breeding in response to the watering regime?	2- 3 surveys (call – back and visual surveys) under favourable weather conditions during breeding season (i.e. October to December) Throughout watering event	Call-back and visual adult surveys. Visual egg and tadpoles surveys. Acoustic recorders to detect calls passively over several days.

3.2	Ensure adequate biomass of macroinvertebrates functional feeding groups and zooplankton to ecological processes and wetland foodwebs	Has an adequate biomass of macroinvertebrate functional feeding groups and zooplankton developed from the watering event?	Yearly, during filling and draw down.	Quantitative macroinvertebrate sampling (e.g. composite Hess samples or samples from artificial substrates) and zooplankton trawls.
Risk		**Monitoring question**	**When**	**Method**
1.3	Water quality	When the wetland is full, is the water quality adequate to support aquatic biota and is intervention required?	Monthly during a watering event; coinciding with photo point monitoring	Multi-meter for EC, pH, DO, temperature; turbidity meter for turbidity. Algal samples and cell counts if BGA is observed.
2.2	Encroachment or dominance of native flora species and weeds	Is the watering regime causing excessive growth of native flora species (e.g. *Typha* spp.) or weeds?	Monthly during watering event	Photo point monitoring; recording GPS points of new growth

10.2. Long term monitoring

Long-term condition monitoring will provide information on whether the watering regime (and other factors) is causing a change in, or maintaining, the overall condition of the wetland (trend over time). As there is currently no formal long-term condition monitoring program in place, Table 18 details monitoring required to demonstrate change in condition over time specifically focusing on the long-term outcomes of the Lake Leaghur EWMP.

Condition monitoring is recommended to be conducted in conjunction with intervention monitoring to comprehensively evaluate any changes to Lake Leaghur.

Table 18. Required long-term condition monitoring for Lake Leaghur

Ecological Objective	**Method**	**When**
All vegetation objectives	Photo points; IWC; vegetation distribution mapping	Photo points annually; IWC and vegetation distribution maps at least once every five years but preferably more frequently (e.g. 2 years)
Risks	**Method**	**When**
Groundwater intrusion or discharge to low-lying surrounding area resulting from elevated groundwater levels.	Review groundwater-related aspects of the site, including environmental risks and impact of adopted watering regime. This should include an appraisal of the movement of the wetting front and salt, impacts on surrounding groundwater levels and neighbouring land, and, if impacts are detected, a water budget that includes estimates of accessions to groundwater. The following monitoring approach is recommended (Bartley 2009): • installing data loggers in selected groundwater bores, to provide data before watering and throughout the wetting and	At least every 7 years or sooner if regional groundwater levels rise.

	drying cycle at the site; • installing data loggers to record surface water level and salinity at the inlet, in the wetland, and at the outlet if there is overflow; • confirming the water level gauge elevation, and use volume rating tables to assist recording level and volume, to verify surface water data logger readings; • recording the inflow and outflow volumes during the watering event; • regular liaison with neighbouring landholders to understand their water use and irrigation practices, and how these change over time; • monitoring neighbouring areas that are considered susceptible to salinisation or waterlogging; • installation of shallow and deep groundwater monitoring bores, at two locations, at the northern end of the site; and • assessing the watertable depth and soil and salinity profile beneath the site floor.	

11. Knowledge gaps and recommendations

The Lake Leaghur EWMP has been developed using the best available information. However, a number of information and knowledge gaps exist which may impact on recommendations and/or information presented in the EWMP. These are summarised below with priority status in Table 19.

Table 19. Knowledge gaps and recommendations for Lake Leaghur

Knowledge Gap	Objective/ Risk	Recommendation	Who	Priority
Objectives				
Determine a suitable option for delivery of environmental water given that the channel 2/2 has been rationalised.	All	Continue investigations into using the private channel for delivery.	CMA, GMW connections; landholder	High
Determine the composition of frog assemblages in Lake Leaghur. Determine if turtles are also using the lake.	1.2, 2.4	Targeted surveys of frogs and turtles have not been recently undertaken at Lake Leaghur. Methods include Wildlife Acoustic Song Meters (audio) and visual surveys (frogs). Swabbing for Taqman real-time PCR assay analysis is also recommended to determine presence of Chytrid fungus in frogs. Fyke nets or cathedral traps for turtles.	CMA or consultant on behalf of CMA	High
Risks				
Determine potential impacts on vegetation communities of re-locating the delivery point if this option is pursued as part of the GMW Connections Project.		Work with GMW to determine if a new delivery point is required as a result of the GMW Connections Project. If so, investigate flow paths and potential behaviour of water to determine ecological impacts to the wetland.	GMW Connections Project	Moderate
To maintain an appropriate extent of *Typha spp.* and *Phragmites australis*, determine best practices for management in Lake Leaghur	2.1	Further investigation and monitoring of ecological responses from *Typha spp.* and *Phragmites australis*, trials and consultation/collaboration with other environmental managers can inform better management of this risk.	CMA and consultant/research body on behalf of CMA	Moderate

12. References

Baldwin, DS, Nielsen, DL, Bowen, PM, & Williams, J, 2005, *Recommended Methods for Monitoring Floodplains and Wetlands*, MDBC Publication No. 72/04, Murray-Darling Basin Commission, Canberra, Australian Capital Territory

Bartley Consulting 2009, *Hydrogeological Overview – Lake Leaghur,* Prepared for the North Central Catchment Management Authority by Bartley Consulting, Heidelberg, Victoria

Bureau of Meteorology 2009, *Climate Statistics for Boort*, Australian Government [online], viewed Nov 2009, <http://www.bom.gov.au/climate/averages/tables/cw_080002.shtml>

Campbell, C. J., Johns, C. V. and Reid, C. J. 2009, *NVIRP Technical Report: Wetland and Waterway Watering Requirements*. Report prepared for the North Central Catchment Management Authority by The Murray-Darling Freshwater Research Centre, November, 118pp

Commonwealth Environmental Water Holder (CEWO) 2016, Environmental water holdings, viewed 24 March 2016, <http://www.environment.gov.au/water/cewo/about/water-holdings>.

Corrick, AH, and Norman, FI, 1980, Wetlands of Victoria. In: *Wetlands and Waterbirds of the Snowy River and Gippsland Lakes Catchments.* Proceedings of the Royal Society of Victoria, 91: 1-15.

Cunningham, SC, MacNally, R, Read, J, Baker, PJ, White, M, Thomson, J. R., & Griffioen, P. 2009, A robust technique for mapping vegetation condition across a major river system, Ecosystems, 12(2), 207-219.

DCE 1991, *Environmental Values, and the Effects of Salinity on the Flora and Fauna of the Boort-West of Loddon Salinity Management Planning Area*, Department of Conservation and Environment, Victoria.

DCFL 1989, Report *No. 1: Conservation value of the wetlands in the Kerang Lakes Area*, Report to Kerang Lakes Area Working Group, Department of Conservation Forests & Lands, Kerang Lakes Assessment Group, Bendigo.

Dedini, M, 2015, Wetland waterbird monitoring in the Kerang region, unpublished data collected for North Central Catchment Management Authority, Huntly, Victoria.

DEWHA 2008, *Water Requirements of Important Wetlands in the Murray-Darling Basin – Initial Overview Assessment,* Final Report, Compiled by Fluvial Systems and Lloyd Environmental, Canberra.

DNRE 2002, *FLOWS- a method for determining environmental water requirements in Victoria*. Prepared by SKM, CRC for Freshwater Ecology and Lloyd Environmental Consultants for DNRE, Melbourne.

DNRE 1997, *Victoria's Biodiversity Directions in Management,* Department of Natural Resources and Environment, Melbourne.

DSE 2011a, Biodiversity Interactive Map, Department of Sustainability and Environment , viewed Feb 2011, <http://mapshare2.dse.vic.gov.au/MapShare2EXT/imf.jsp?site=bim >

DSE 2011b, Ecological Vegetation Class (EVC) Benchmarks for each Bioregion, Department of Sustainability and Environmen, viewed Feb 2011, <http://www.dse.vic.gov.au/dse/index.htm>

DSE 2010a, Victorian Biodiversity Atlas Fauna Records, Produced by Viridans Biological Databases and the Department of Sustainability and Environment, Victoria.

DSE 2010b, Victorian Biodiversity Atlas Flora Records, Produced by Viridans Biological Databases and the Department of Sustainability and Environment, Victoria.

DSE 2009a, Data Source: 'WETLAND_1788', © The State of Victoria, Department of Sustainability and Environment. The contribution of the Royal Botanical Gardens Melbourne to the data is acknowledged. Accessed: January 2009.

DSE 2009b, Data Source: 'WETLAND_1994', © The State of Victoria, Department of Sustainability and Environment. The contribution of the Royal Botanical Gardens Melbourne to the data is acknowledged. Accessed: January 2009.Ebird 2016, *Ebird Hotspot – Lake Leaghur*, viewed March 2016, <http://ebird.org/ebird/hotspot/L2543472>

Ecos Environmental Consulting 2007, *Boort District Wetland Vegetation Assessment*, prepared for North Central Catchment Management Authority, Ecos Environmental Consulting, Balwyn, Victoria

EPA (Victorian Environment Protection Authority) 2010, *Environmental Quality Guidelines for Victorian Lakes, v*iewed January 2016, <http://www.epa.vic.gov.au/our-work/publications/publication/2010/february/1302>

Hillemacher, M, and Ivezich, M, 2008, Boort District Wetlands, Environmental Water Delivery Options Assessment. Report P108022_R01 by Alluvium for North Central CMA.

Lugg, A, Heron, A, O'Donnell, T, & Fleming G, 1993, Environmental values and the effects of salinity on the flora and fauna of the Boort-West of Loddon Catchment. Department of Conservation and Natural Resources, Bendigo

Loddon Plains Community Bird Monitoring Project (LPCBM) 2016, *Lake Leaghur Site Report, January 2016*, veiwed Jan 2016, <http://www.lpln.org/goanna-project/community-bird-monitoring-project/bird-monitoring-data/>

North Central CMA 2015a, *Lake Leaghur Environmental Watering Plan*, Prepared for the Northern Victoria Irrigation Renewal Project, North Central Catchment Management Authority, Huntly, Victoria.

North Central CMA 2015b, *North Central Climate Change Adaptation and Mitigation Plan 2015-2018*, North Central Catchment Management Authority, Huntly, Victoria.

North Central CMA 2014, *North Central Waterway Strategy 2014-22*, North Central Catchment Management Authority, Huntly, Victoria.

North Central CMA 2012, *North Central Regional Catchment Strategy 2013-19*, North Central Catchment Management Authority, Huntly, Victoria.

North Central CMA 2008, 2008/2009 Annual Watering Plan Bulk Entitlement (Loddon River – Environmental Reserve) Order 2005, Final Draft for Endorsement by Minister for Environment and Climate Change, North Central Catchment Management Authority, Huntly

NVIRP 2010, *Water Change Management Framework,* Version 2, Northern Victoria Irrigation Renewal Project, May 2010, Shepparton, Victoria

O'Brien, R, & Joyce, A, 2002, *Loddon Wetland Water Supply Issues Paper Meeting No. 5 20th February 2002,* prepared for the Loddon Bulk Entitlement Project Group by the Department of Primary Industries and Department of Sustainability and Environment, Victoria.

Parks Victoria 1998, *Leaghur State Park Management Plan August 1998,* Parks Victoria, Bendigo, Victoria

Price Merrett Consulting 2006, *Lake Leaghur Contour Survey*, prepared for North Central Catchment Management Authority. Price Merrett Consulting July, 2006

SKM 2008, *Food Bowl Modernisation Project – Environmental Referrals*, Document prepared for the Department of Sustainability and Environment, 13th November, Melbourne.

SKM 2005, *Gunbower Forest Flooding Enhancement*, Report prepared for the North Central Catchment Management Authority, Huntly.

SKM 2001, *Lake Leaghur Environmental Assessment*, Final report, Goulburn– Murray Water.

VEAC 2008, *River Red Gum Forests Investigation*, Final report, Victorian Environmental Assessment Council, July, Melbourne.

Victorian Environmental Water Holder (VEWH) 2016, *Environmental water planning*, viewed Feb 2016, <http://www.vewh.vic.gov.au/managing-the-water-holdings/planning>

VEWH 2012, *Water Holdings,* viewed Feb 2016, <http://www.vewh.vic.gov.au/managing-the-water-holdings

13. Abbreviations and acronyms

BE	Bulk Entitlement
Bonn	The Convention on the Conservation of Migratory Species of Wild Animals (also known as the Bonn Convention or CMS)
CAMBA	China-Australia Migratory Bird Agreement
CEWO	Commonwealth Environmental Water Office
CMA	Catchment Management Authority
DELWP	Department of Environment, Land, Water and Planning
DEPI	Department of Environment and Primary Industries (Now an amalgamation DELWP in 2015)
DPI	Department of Primary Industries (Now an amalgamation DELWP in 2015)
DSE	Department of Sustainability and Environment (Now DELWP in 2015)
EPBC	Environment Protection and Biodiversity Conservation Act 1999 (Cth)
EVC	Ecological Vegetation Class
EWMP	Environmental Water Management Plan
FFG	Flora and Fauna Guarantee Act 1988 (Vic)
FSL	Full supply level
GIS	Geographical Information System
GMW	Goulburn Murray Water
GMWCP	Goulburn Murray Water Connections Project
HRWS	High Reliability Water Share
JAMBA	Japan-Australia Migratory Bird Agreement
LRWS	Low Reliability Water Share
MEWAG	Central Murray Wetlands Environmental Water Advisory Group
MDBA	Murray-Darling Basin Authority (formerly Murray-Darling Basin Commission, MDBC)
ML	Megalitre (one million litres)
ML/d	Megalitres per day
NCWS	North Central Waterway Strategy
ROKAMBA	Republic of Korea-Australia Migratory Bird Agreement
RCS	Regional Catchment Strategy
SWP	Seasonal Watering Proposal
VEWH	Victorian Environmental Water Holder
VWMS	Victorian Waterway Management Strategy

Appendix 1. Legislative Framework

International agreements and conventions

Ramsar Convention on Wetlands (Ramsar)

The Australian Government is a Contracting Party to the convention, which is an inter-governmental treaty whose mission is “the conservation and wise use of all wetlands through local, regional and national actions and international cooperation, as a contribution towards achieving sustainable development throughout the world".

World Heritage Sites

Heritage includes places, values, traditions, events and experiences that capture where we've come from, where we are now and gives context to where we are headed as a community. The World Heritage Convention aims to promote cooperation among nations to protect heritage from around the world that is of such outstanding universal value that its conservation is important for current and future generations. It is intended that, unlike the seven wonders of the ancient world, properties on the World Heritage List will be conserved for all time (DEWHA 2008a).

East Asian-Australasian Flyway Sites

Australia provides critical non-breeding habitat for millions of migratory waterbirds each year. Migratory waterbirds include species such as plovers, sandpipers, stints and curlews. The corridor through which these waterbirds migrate is known as the East Asian-Australasian Flyway.

To ensure their conservation, the Australian Government has fostered international cooperation through the recently launched East Asian-Australasian Flyway Partnership. Under the Flyway Partnership, the site network for shorebirds has been combined into a single network, referred to as the East Asian–Australasian Flyway Site Network.

Bilateral migratory bird agreements

Australia is a signatory to the following international bilateral migratory bird agreements:

- Japan-Australia Migratory Bird Agreement (JAMBA);
- China-Australia Migratory Bird Agreement (CAMBA); and
- Republic of Korea-Australia Migratory Bird Agreement (ROKAMBA).

These agreements require that the parties protect migratory birds by:

- limiting the circumstances under which migratory birds are taken or traded;
- protecting and conserving important habitats;
- exchanging information; and
- building cooperative relationships.

Convention on the Conservation of Migratory Species of Wild Animals (Bonn)

This convention (known as the Bonn Convention or CMS) aims to conserve terrestrial, marine and avian migratory species throughout their range. It is an intergovernmental treaty, concluded under the aegis of the United Nations Environment Programme, concerned with the conservation of wildlife and habitats on a global scale. The Convention was signed in 1979 in Bonn, Germany, and entered into force in 1983.

Commonwealth legislation

Environment Protection and Biodiversity Conservation Act 1999 (EPBC)

This is the key piece of legislation pertaining to biodiversity conservation within Australia. It provides a legal framework to protect and manage nationally and internationally important flora, fauna, ecological communities and heritage places - defined in the EPBC Act as matters of national environmental significance.

Water Act 2007 (Commonwealth Water Act)

This establishes the Murray-Darling Basin Authority (MDBA) with the functions and powers, including enforcement powers, needed to ensure that Basin water resources are managed in an integrated and sustainable way.

Aboriginal and Torres Strait Islander Heritage Protection Act 1984

This aims to preserve and protect areas and objects in Australia and Australian waters that are of particular significance to indigenous people from injury or desecration.

Nationally Important Wetlands

Victoria has a number of waterways of National importance as described in A Directory of Important Wetlands in Australia (Environment Australia, 2001).

There are 159 wetlands in Victoria listed in the Directory.

Living Murray Icon Sites

The Living Murray was established in 2002 in response to evidence that the health of the River Murray system is in decline. The Living Murray's first stage focuses on improving the environment at six 'icon sites' along the River:

- Barmah-Millewa Forest;
- Gunbower-Koondrook-Perricoota Forest;
- Hattah Lakes;
- Chowilla Floodplain and Lindsay-Wallpolla Islands;
- Lower Lakes, Coorong and Murray Mouth; and
- River Murray Channel.

The sites were chosen for their high ecological value—most are listed as internationally significant wetlands under the Ramsar convention—and also their cultural significance to Indigenous people and the broader community (MDBC, 2006).

HEVAE

Through National Water Initiative (NWI) commitments, a toolkit for identifying high ecological value aquatic ecosystems (HEVAE) has been developed so that national consistency may be applied. Five core criteria are used to develop HEVAE sites across a range of scales and ecosystems:

- Diversity
- Distinctiveness
- Vital habitat
- Naturalness
- Representativeness.

The HEVAE toolkit is saved at http://www.environment.gov.au/resource/aquatic-ecosystems-toolkit-module-3-guidelines-identifying-high-ecological-value-aquatic

National Heritage Sites

The National Heritage List has been established to list places of outstanding heritage significance to Australia. It includes natural, historic and Indigenous places that are of outstanding national heritage value to the Australian nation (DEWHA 2008).

State legislation and listings

Flora and Fauna Guarantee Act 1988 (FFG)

This is the key piece of Victorian legislation for the conservation of threatened species and communities and for the management of potentially threatening processes.

Advisory lists of rare or threatened species in Victoria (DSE)

Three advisory lists are maintained by DSE for use in a range of planning process and in setting priorities for actions to conserve biodiversity. Unlike other threatened species lists, there are no legal requirements or consequences that flow from inclusion of a species on an advisory list. The advisory lists comprise:

- Advisory List of Rare or Threatened Plants In Victoria – 2005
- Advisory List of Threatened Vertebrate Fauna in Victoria - 2007
- Advisory List of Threatened Invertebrate Fauna in Victoria - 2009

Environmental Effects Act 1978

Potential environmental impacts of a proposed development are subject to assessment and approval under this Act. A structural works program and any associated environmental impacts would be subject to assessment and approval under the Act.

Planning and Environment Act 1987

This controls the removal or disturbance to native vegetation within Victoria by implementation of a three-step process of avoidance, minimisation and offsetting.

Water Act 1989 (Victorian Water Act)

This is the key piece of legislation that governs the way water entitlements are issued and allocated in Victoria. The Act also identifies water that is to be kept for the environment under the Environmental Water Reserve. The Act provides a framework for defining and managing Victoria's water resources.

Aboriginal Heritage Act 2006

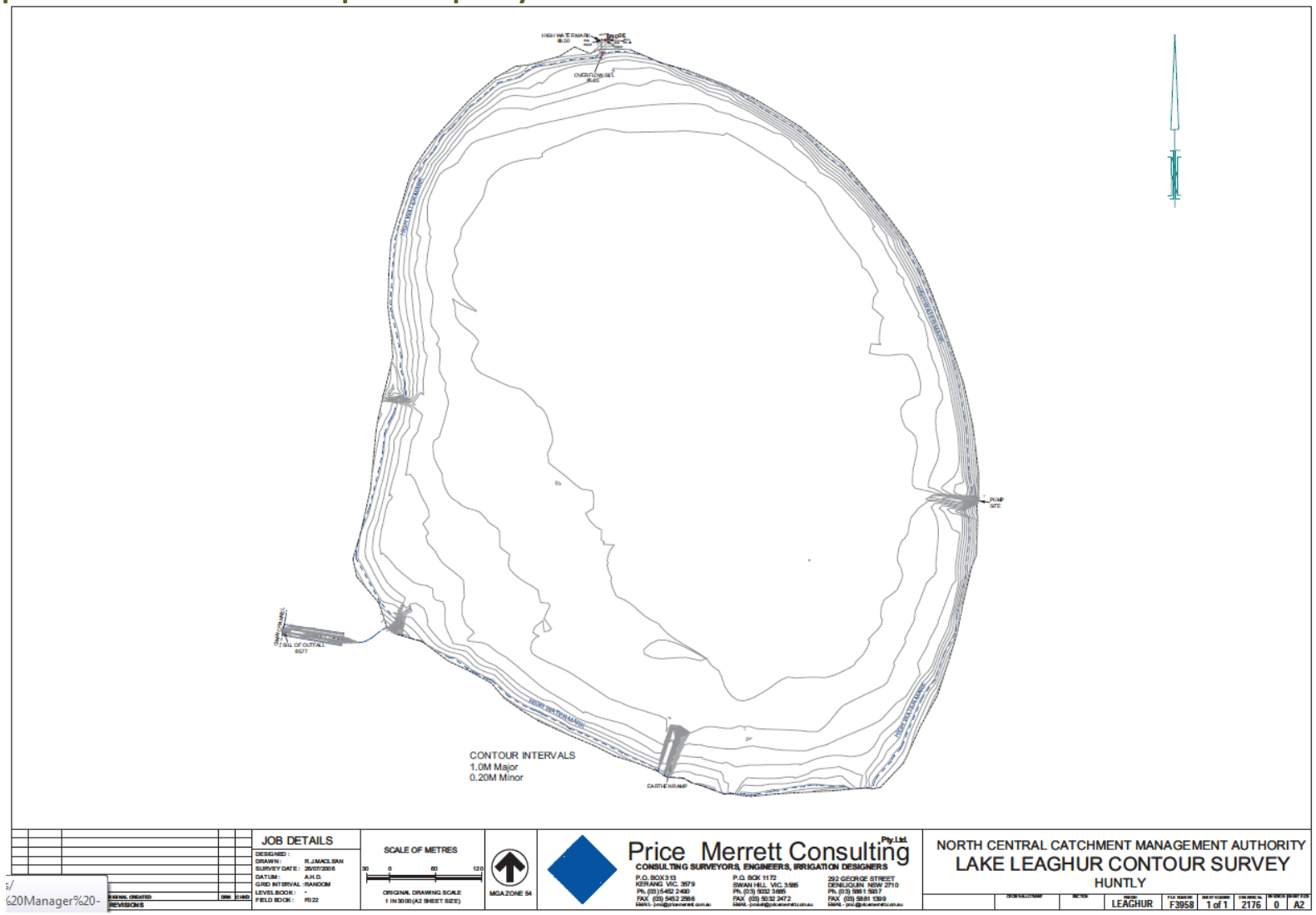
All Aboriginal places, objects and human remains in Victoria are protected under this Act.

Other relevant legislation

The preceding legislation operates in conjunction with the following other Victorian legislation to influence the management and conservation of Victoria's natural resources as well as outline obligations with respect to obtaining approvals for structural works:

- Environment Protection Act 1970
- Catchment and Land Protection Act 1994
- Heritage Act 1995
- Conservation, Forests and Lands Act 1987
- Land Act 1958
- Heritage Rivers Act 1992
- Wildlife Act 1975
- Murray Darling Basin Act 1993
- National Parks Act 1975
- Parks Victoria Act 1998
- Forests Act 1958

Appendix 2. Contour Map and Capacity Table



LAKE LEAGHUR

RATING CURVE TABLE

ELEVATION AHD	SURFACE AREA (Ha)	VOLUME STORED MEGALITRES	
84.50	8.587	1.67	
84.60	30.557	23.57	
84.70	38.281	58.02	
84.80	43.540	99.00	
84.90	47.349	144.55	
85.00	50.027	193.24	
85.10	51.859	244.18	
85.20	53.384	296.82	
85.30	54.602	350.84	
85.40	55.607	405.96	
85.50	56.426	461.99	
85.60	57.174	518.79	
85.70	57.889	576.32	
85.80	58.590	634.57	
85.85	58.925	664.24	OUTFALL SILL ELEVATION
85.90	59.248	693.49	
86.00	59.797	753.02	
86.10	60.186	813.03	
86.20	60.601	873.36	
86.30	61.085	933.90	
86.40	61.590	994.54	
86.50	62.060	1055.52	HIGH WATER MARK ON GUAGE

Note - volumes are cumulative volumes

Appendix 3. Species lists

Table 20. Fauna species recorded within 1km buffer zone of Lake Leaghur

Common name	Scientific name	Date of last record	Source
Amphibians			
Spotted Marsh Frog (race unknown)	Limnodynastes tasmaniensis	*1995*	DELWP (2016)
Mammals			
Water Rat	*Hydromys chrysogaster*	*1990*	DELWP (2016)
Reptiles			
Eastern Long-necked Turtle	***Chelodina longicollis***	***1990***	**DELWP (2016)**
Striped Legless Lizard	***Delma impar***	***Unknown***	**NCCMA (2015)**
Fish			
European Carp	*Cyprinus carpio*	*1991*	SKM (2001)
Flat Headed Gudgeon	*Philypnodon grandiceps*	*2001*	SKM (2001)
Freshwater Catfish	***Tandanus tandanus***	***1957***	**DELWP (2016)**
Goldfish	*Carassius auratus*	*2001*	SKM (2001)
Mosquito fish	*Gambusia holbrooki*	*2001*	SKM (2001)
Redfin	*Perca fluviatilis*	*1981*	DELWP (2016)
Water dependant birds			
Australasian Grebe	*Tachybaptus novaehollandiae*	*2013*	eBird Website (2016)
Australasian Shoveler	***Anas rhynchotis***	*2014*	eBird Website (2016)
Australian Pelican	*Pelecanus conspicillatus*	*2014*	Dendini (2015)
Australian Reed-Warbler	*Acrocephalus stentorius*	*2013*	eBird Website (2016)
Australian shelduck	*Tadorna tadornoides*	*2014*	Dendini (2015)
Australian White Ibis	*Threskiornis molucca*	*2013*	Dendini (2015)
Australian Wood Duck	*Chenonetta jubata*	*2015*	eBird Website (2016)
Banded Stilt	*Cladorhynchus leucocephalus*	*2002*	eBird Website (2016)
Black Swan	*Cygnus atratus*	*2013*	Dendini (2015)
Black tailed Native Hen	*Tribonyx ventralis*	*2014*	Dendini (2015)
Black-fronted dotteral	*Elseyornis melanops*	*2014*	Dendini (2015)
Black-winged stilt	*Himantopus himantopus*	*2014*	Dendini (2015)
Blue-billed Duck	***Oxyura australis***	***2001***	**DELWP (2016)**
Caspian Tern	***Anas castanea***	***2011***	**Dendini (2015)**
Clamorous Reed Warbler	***Acrocephalus stentoreus***	***2001***	**DELWP (2016)**
Common Greenshank	***Tringa nebularia***	***1999***	**DELWP (2016)**
Darter	*Anhinga novaehollandiae*	*2013*	Dendini (2015)
Dusky Moorhen	*Gallinula tenebrosa*	*2012*	Dendini (2015)
Eastern Great Egret	***Ardea modesta***	***2001***	**DELWP (2016)**
Eurasian Coot	*Fulica atra*	*2013*	Dendini (2015)
Freckled Duck	***Stictonetta naevosa***	*2013*	eBird Website (2016)
Glossy Ibis	***Plegadis falcinellus***	***2001***	**DELWP (2016)**
Great Cormorant	*Phalacrocorax carbo*	*2014*	eBird Website (2016)
Great Crested Grebe	*Podiceps cristatus*	*2013*	Dendini (2015)
Great Egret	*Ardea alba*	*2013*	Dendini (2015)
Grey Teal	*Anas gracilis*	*2014*	Dendini (2015)
Hardhead	***Aythya australis***	***2013***	**Dendini (2015)**
Hoary-headed Grebe	*Poliocephalus poliocephalus*	*2013*	Dendini (2015)
Intermediate Egret	***Ardea intermedia***	***2000***	**DELWP (2016)**

Common name	Scientific name	Date of last record	Source
Little Black Cormorant	*Phalacrocorax sulcirostris*	*2013*	Dendini (2015)
Little Egret	***Egretta garzetta nigripes***	***2001***	**DELWP (2016)**
Little Pied Cormorant	*Microcarbo melanoleucos*	*2013*	eBird Website (2016)
Marsh sandpiper	***Tringa stagnatilis***	***2014***	**eBird Website (2016)**
Musk Duck	***Biziura lobata***	***2011***	**Dendini (2015)**
Pacific Black Duck	*Anas superciliosa*	*2013*	Dendini (2015)
Pectoral Sandpiper	***Calidris melanotos***	***2014***	**eBird Website (2016)**
Pied Cormorant	*Phalacrocorax varius*	*2012*	Dendini (2015)
Pink-eared Duck	*Malacorhynchus membranaceus*	*2014*	Dendini (2015)
Purple Swamphen	*Porphyrio porphyrio*	*2001*	DELWP (2016)
Red-capped Plover	*Charadrius ruficapillus*	*2014*	eBird Website (2016)
Red-necked Avocet	*Recurvirostra novaehollandiae*	*2014*	Dendini (2015)
Red-necked Stint	***Calidris ruficollis***	*2014*	eBird Website (2016)
Royal Spoonbill	***Platalea regia***	***2013***	**Dendini (2015)**
Ruff (Reeve)	***Philomachus pugnax***	***2014***	**eBird Website (2016)**
Sacred Kingfisher	*Todiramphus sanctus*	*2001*	DELWP (2016)
Silver Gull	*Chroicocephalus novaehollandiae*	*2014*	Dendini (2015)
Straw-necked Ibis	*Threskiornis spinicollis*	*2012*	eBird Website (2016)
Swamp Harrier	*Circus approximans*	*2015*	eBird Website (2016)
Whiskered Tern	***Chlidonias hybridus javanicus***	***2013***	**eBird Website (2016)**
White-bellied Sea-Eagle	***Haliaeetus leucogaster***	***2013***	**Dendini (2015)**
White-faced Heron	*Egretta novaehollandiae*	*2014*	LCPBM (2016)
White-necked Heron	*Ardea pacifica*	*2015*	eBird Website (2016)
Yellow Spoonbill	*Platalea flavipes*	*2014*	Dendini (2015)
Terrestrial birds			
Australian Magpie	*Gymnorhina tibicen*	*2015*	LCPBM (2016)
Australian Raven	*Corvus coronoides*	*2014*	eBird Website (2016)
Black Kite	*Milvus migrans*	*2013*	eBird Website (2016)
Black-chinned Honeyeater	***Melithreptus gularis***	***Unknown***	**NCCMA (2015)**
Black-eared Cuckoo	***Chrysococcyx osculans***	***Unknown***	**NCCMA (2015)**
Black-faced Cuckoo-shrike	*Coracina novaehollandiae*	*2014*	LCPBM (2016)
Black-shouldered Kite	*Elanus axillaris*	*2015*	eBird Website (2016)
Brown Falcon	*Falco berigora*	*2015*	eBird Website (2016)
Brown Goshawk	*Accipiter fasciatus*	*2014*	LCPBM (2016)
Brown Quail	*Coturnix ypsilophora*	*2015*	LCPBM (2016)
Brown Treecreeper (south-eastern ssp.)	***Climacteris picumnus victoriae***	***2015***	**LCPBM (2016)**
Cockatiel	*Nymphicus hollandicus*	*2013*	eBird Website (2016)
Collared Sparrowhawk	*Accipiter cirrocephalus*	*2011*	eBird Website (2016)
Common Bronzewing	*Phaps chalcoptera*	*2014*	eBird Website (2016)
Common Starling	*Sturnus vulgaris*	*2015*	LCPBM (2016)
Crested Bellbird	***Oreoica gutturalis***	***Unknown***	**NCCMA (2015)**
Crested Pigeon	*Ocyphaps lophotes*	*2015*	LCPBM (2016)
Diamond Firetail	***Stagonopleura guttata***	***Unknown***	**NCCMA (2015)**
Dusky Woodswallow	*Artamus cyanopterus*	*2013*	eBird Website (2016)
Eastern Rosella	*Platycercus eximius*	*2015*	eBird Website (2016)
Galah	*Eolophus roseicapilla*	*2015*	LCPBM (2016)
Golden Whistler	*Pachycephala pectoralis*	*2001*	DELWP (2016)

Common name	Scientific name	Date of last record	Source
Golden-headed Cisticola	*Cisticola exilis*	*2015*	LCPBM (2016)
Grey Shrike-thrush	*Colluricincla harmonica*	*2015*	eBird Website (2016)
Grey-crowned Babbler	***Pomatostomus temporalis***	***2003***	**eBird Website (2016)**
Hooded Robin	***Melanodryas cucullata***	***Unknown***	**NCCMA (2015)**
House Sparrow	*Passer domesticus*	*2015*	eBird Website (2016)
Laughing Kookaburra	*Dacelo novaeguineae*	*2015*	LCPBM (2016)
Little Friarbird	*Philemon citreogularis*	*2013*	eBird Website (2016)
Little Grassbird	*Megalurus gramineus*	*2014*	LCPBM (2016)
Little Raven	*Corvus mellori*	*2015*	LCPBM (2016)
Long-billed Corella	*Cacatua tenuirostris*	*2015*	LCPBM (2016)
Magpie-lark	*Grallina cyanoleuca*	*2015*	LCPBM (2016)
Major Mitchell's Cockatoo	***Lophocroa leadbeateri***	***Unknown***	**NCCMA (2015)**
Masked lapwing	*Vanellus miles*	*2014*	eBird Website (2016)
Nankeen Kestrel	*Falco cenchroides*	*2015*	LCPBM (2016)
Noisy Miner	*Manorina melanocephala*	*2015*	LCPBM (2016)
Peaceful Dove	*Geopelia striata*	*2015*	LCPBM (2016)
Pied Butcherbird	*Cracticus nigrogularis*	*2015*	eBird Website (2016)
Rainbow Bee-eater	***Merops ornatus***	***2012***	**eBird Website (2016)**
Red kneed dotterel	*Erythrogonys cinctus*	*2014*	Dendini (2015)
Red Wattlebird	*Anthochaera carunculata*	*2015*	eBird Website (2016)
Red-rumped Parrot	*Psephotus haematonotus*	*2015*	LCPBM (2016)
Restless Flycatcher	*Myiagra inquieta*	*2010*	eBird Website (2016)
Rufous Whistler	*Pachycephala rufiventris*	*2015*	eBird Website (2016)
Sharp tailed sandpiper	***Calidris acuminata***	***2014***	**Dendini (2015)**
Southern Boobook	*Ninox boobook*	*2014*	LCPBM (2016)
Speckled Warbler	***Chthonicola sagittata***	***Unknown***	**NCCMA (2015)**
Striated Pardalote	*Pardalotus striatus*	*2015*	eBird Website (2016)
Sulphur-crested Cockatoo	*Cacatua galerita*	*2014*	eBird Website (2016)
Superb Fairy-wren	*Malurus cyaneus*	*2015*	LCPBM (2016)
Swift Parrot	***Lathamus discolor***	***Unknown***	**NCCMA (2015)**
Tree Martin	*Petrochelidon nigricans*	*2014*	LCPBM (2016)
Wedge-tailed Eagle	*Aquila audax*	*2014*	eBird Website (2016)
Welcome Swallow	*Petrochelidon neoxena*	*2015*	LCPBM (2016)
Whistling Kite	*Haliastur sphenurus*	*2015*	LCPBM (2016)
White fronted chat	*Epthianura albifrons*	*2014*	Dendini (2015)
White-breasted Woodswallow	*Artamus leucorynchus*	*2003*	eBird Website (2016)
White-plumed Honeyeater	*Lichenostomus penicillatus*	*2015*	LCPBM (2016)
White-winged Chough	*Corcorax melanorhamphos*	*2014*	LCPBM (2016)
Willie Wagtail	*Rhipidura leucophrys*	*2015*	LCPBM (2016)

Table 21. Flora species recorded within 1km buffer zone of Lake Leaghur

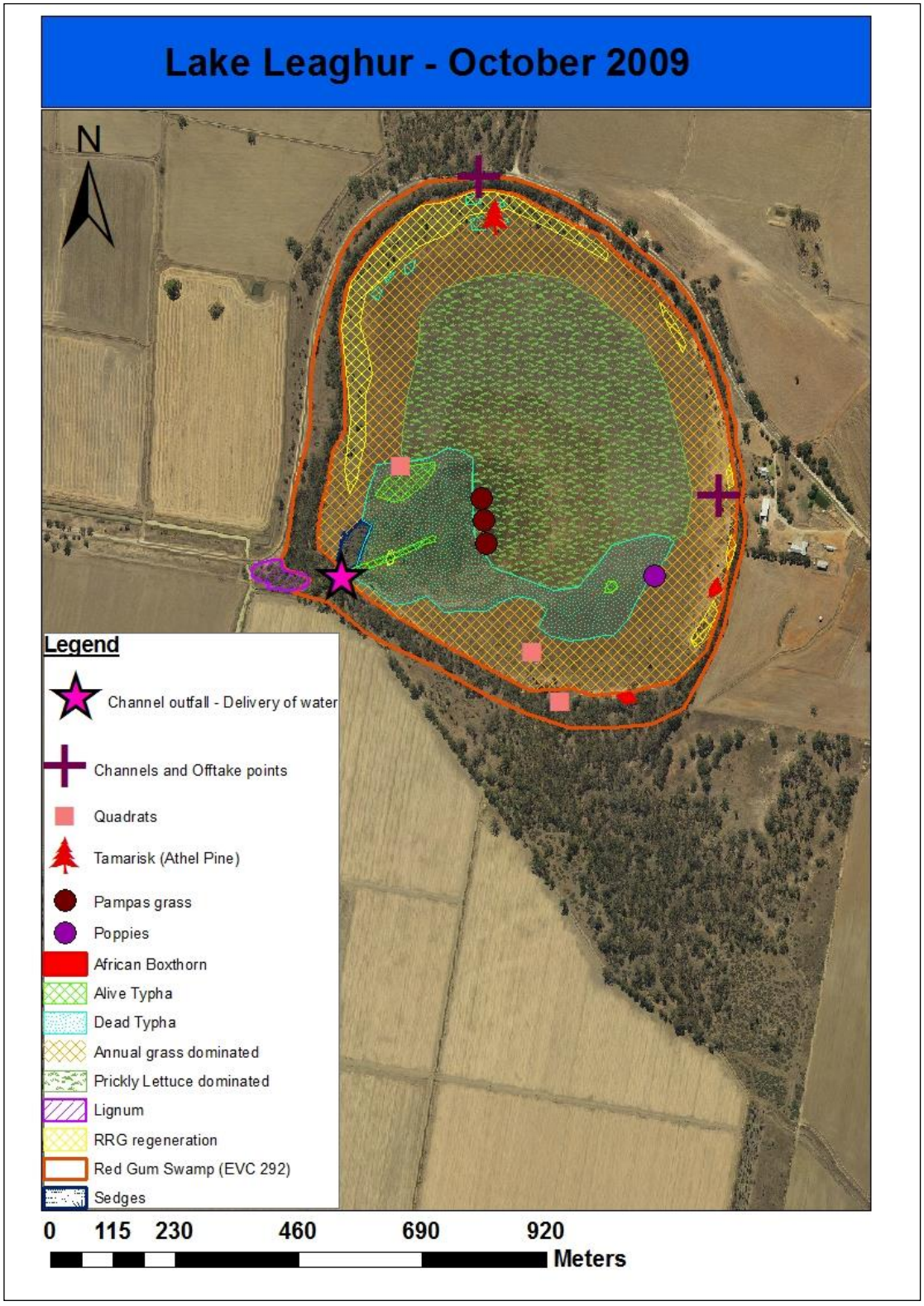
Common name	Scientific name	Date of last record	Source
Water-dependent species			
Ferny Small-flower Buttercup	***Ranunculus pumilio***	***1993***	**DELWP (2016)**
Blunt Pondweed	*Potamogeton ochreatus*	*Unknown*	NCCMA (2015)
Bulrush	*Typha spp.*	*1993*	DELWP (2016)
Cane Grass	***Eragrostis australica***	***2009***	**Campbell (2009)**
Clammy Goosefoot	*Chenopodium pumilo*	*2001*	SKM (2001)
Club Sedge	*Isolepis spp.*	*1990*	DELWP (2016)
Common Nardoo	*Marsilea drummondii*	*1993*	DELWP (2016)
Common Spike-sedge	*Eleocharis acuta*	*2001*	SKM (2001)
Duckweed	*Spirodela oligorrhiza*	*Unknown*	NCCMA (2015)
Eel Grass	*Vallisneria americana var. americana*	*1990*	DELWP (2016)
Fennel Pondweed	*Potamogeton pectinatus*	*Unknown*	NCCMA (2015)
Finger Rush	*Juncus subsecundus*	*2007*	Ecos (2007)
Floating Pondweed	*Potamogeton tricarinatus s.l.*	*1993*	DELWP (2016)
Knob Sedge	*Carex inversa*	*1993*	DELWP (2016)
Lesser Joyweed	*Alternanthera denticulata*	*Unknown*	NCCMA (2015)
Narrow-leaf Cumbungi	*Typha domingensis*	*2007*	Ecos (2007)
Narrow-leaf Nardoo	*Marsilea costulifera*	*1993*	DELWP (2016)
Pacific Azolla	*Azolla filiculoides*	*1990*	DELWP (2016)
Pale Knotweed	*Persicaria lapathifolia*	*2007*	Ecos (2007)
Peppercress	***Lepidium pseudohyssopifolium***	***2007***	**Ecos (2007)**
Plains Rush	*Juncus semisolidus*	*1990*	DELWP (2016)
Poong'ort	*Carex tereticaulis*	*1993*	DELWP (2016)
Red Water-milfoil	*Myriophyllum verrucosum*	*2001*	SKM (2001)
Rigid Panic	*Walwhalleya proluta*	*1993*	DELWP (2016)
River Buttercup	*Ranunculus inundatus*	*1990*	DELWP (2016)
River Red Gum	*Eucalyptus camaldulensis*	*2007*	Ecos (2007)
Slender Knotweed	*Persicaria decipiens*	*2007*	Ecos (2007)
Small Knotweed	*Polygonum plebeium*	*2001*	SKM (2001)
Small Loosestrife	*Lythrum hyssopifolia*	*1993*	DELWP (2016)
Small Spike-sedge	*Eleocharis pusilla*	*1993*	DELWP (2016)
Southern Cane-grass	*Eragrostis infecunda*	*2007*	Ecos (2007)
Spiny Flat-sedge	*Cyperus gymnocaulos*	*2007*	Ecos (2007)
Spiny Lignum	***Muehlenbeckia horrida subsp. Horrida***	***Unknown***	**NCCMA (2015)**
Swamp Buttercup	***Ranunculus undosus***	***1993***	**DELWP (2016)**
Swamp Starwort	*Stellaria angustifolia*	*1993*	DELWP (2016)
Tall Fireweed	***Senecio runcinifolius***	***Unknown***	**NCCMA (2015)**
Tall Spike-sedge	*Eleocharis sphacelata*	*1993*	DELWP (2016)
Tangled Lignum	*Muehlenbeckia florulenta*	*2007*	Ecos (2007)
Umbrella Sedge	*Cyperus eragrostis*	*2007*	Ecos (2007)
Unidentified Schoenoplectus sp.	*Schoenoplectus sp.*	*2007*	Ecos (2007)
Upright Water-milfoil	*Myriophyllum crispatum*	*Unknown*	NCCMA (2015)
Water Ribbons	*Triglochin procerum s.l.*	*Unknown*	NCCMA (2015)
Yellow Rush	*Juncus flavidus*	*2007*	Ecos (2007)
Terrestrial species			
Berry Saltbush	*Atriplex semibaccata*	*2007*	Ecos (2007)
Blown Grass	*Lachnagrostis filiformis*	*2007*	Ecos (2007)

Common name	Scientific name	Date of last record	Source
Branching Groundsel	***Scenecio cunninghamii var. cunninghamii***	***2009***	**Campbell (2009)**
Bristly Wallaby-grass	*Austrodanthonia setacea s.l.*	*Unknown*	NCCMA (2015)
Brown-back Wallaby-grass	*Austrodanthonia duttoniana*	*2007*	Ecos (2007)
Cherry Ballart	*Exocarpus cupressiformis*	*Unknown*	NCCMA (2015)
Common Everlasting	***Helichrysum apiculatum***	***Unknown***	**NCCMA (2015)**
Common Wallaby-grass	*Rytidosperma caespitosum*	*2007*	Ecos (2007)
Copperburr	*Sclerolaena sp.*	*Unknown*	NCCMA (2015)
Cotton Fireweed	***Senecio quadridentatus***	***2007***	**Ecos (2007)**
Couch	*Cynodon dactylon*	*2007*	Ecos (2007)
Dandelion	*Taraxacum spp.*	*1990*	DELWP (2016)
Dense Crassula	*Crassula colorata*	*Unknown*	NCCMA (2015)
Feather Spear-grass	*Austrostipa elegantissima*	*Unknown*	NCCMA (2015)
Forde Poa	*Poa fordeana*	*1990*	DELWP (2016)
Grassland Wood-sorrel	*Oxalis perennans*	*1993*	DELWP (2016)
Groundsel	*Senecio sp.*	*2007*	Ecos (2007)
Hairy Carpet-weed	*Glinus lotoides*	*2001*	SKM (2001)
Jersey Cudweed	***Helichrysum luteoalbum***	***Unknown***	**NCCMA (2015)**
Knobby Club-sedge	*Ficinia nodosa*	*Unknown*	NCCMA (2015)
Long Erngium	*Eryngium plantaginuem*	*Unknown*	Lugg et al (1993)
Mallee Love-grass	*Eragrostis dielsii*	*Unknown*	NCCMA (2015)
New Holland Daisy	***Vittadinia sp.***	***Unknown***	**NCCMA (2015)**
Nodding Saltbush	*Einardia nutans ssp. nutans*	*Unknown*	NCCMA (2015)
Paper Sunray	***Rhodanthe corymbiflora***	***Unknown***	**NCCMA (2015)**
Poison Pratia	*Lobelia concolor*	*1993*	DELWP (2016)
Prickly Saltwort	*Salsola tragus*	*Unknown*	NCCMA (2015)
Rough Spear-grass	*Austrostipa scabra ssp. falcata*	*Unknown*	NCCMA (2015)
Ruby Saltbush	*Enchylaena tomentosa var. tomentosa*	*Unknown*	NCCMA (2015)
Saltbush	*Atriplex sp.*	*Unknown*	NCCMA (2015)
Short-leaf Bluebush	*Maireana brevifolia*	*Unknown*	NCCMA (2015)
Slender Dock	*Rumex brownii*	*1993*	DELWP (2016)
Slender-fruit Saltbush	*Atriplex leptocarpa*	*2007*	Ecos (2007)
Star Fruit	*Damasonium minus*	*Unknown*	NCCMA (2015)
Twin-leaf Bedstraw	*Asperula gemella*	*1990*	DELWP (2016)
Variable Sida	*Sida currugata*	*2001*	SKM (2001)
Willow-herb	*Epilobium sp.*	*2001*	SKM (2001)
Windmill Grass	*Chloris truncata*	*Unknown*	NCCMA (2015)
Exotic water-dependent species			
Aster Weed	*Aster subulatus*	*2007*	Ecos (2007)
Bathurst Burr	*Xanthium spinosum*	*1990*	DELWP (2016)
Celery Buttercup	*Ranunculus sceleratus subsp. sceleratus*	*2001*	DELWP (2016)
Common Peppercress	*Lepidium africanum*	*1993*	DELWP (2016)
Curled Dock	*Rumex crispus*	*1993*	DELWP (2016)
Drain Flat-sedge	*Cyperus eragrostis*	*Unknown*	NCCMA (2015)
Paspalum	*Paspalum dilatatum*	*1990*	DELWP (2016)
Spiny Rush	*Juncus acutus subsp. acutus*	*1990*	DELWP (2016)
Water Buttons	*Cotula coronopifolia*	*Unknown*	NCCMA (2015)
Water Couch	*Paspalum distichum*	*1993*	DELWP (2016)

Common name	Scientific name	Date of last record	Source
Exotic terrestrial species			
African Box-thorn	*Lycium ferocissimum*	*1993*	DELWP (2016)
Barley Grass	*Hordeum sp.*	*Unknown*	NCCMA (2015)
Bearded Oat	*Avena barbata*	*1993*	DELWP (2016)
Black Nightshade	*Solanum nigrum*	*2001*	SKM (2001)
Blue Sow-thistle	*Sonchus asper ssp. glaucescens*	*Unknown*	NCCMA (2015)
Burr Medic	*Medicago polymorpha*	*2001*	SKM (2001)
Canary Grass	*Phalaris aquatica*	*2007*	Ecos (2007)
Catís Ear	*Hypochoeris radicata*	*2007*	Ecos (2007)
Common Sow-thistle	*Sonchus oleraceus*	*1993*	NCCMA (2015)
Giant Mustard	*Rapistrum ruginosum*	*2007*	Ecos (2007)
Great Brome	*Bromus diandrus*	*1993*	DELWP (2016)
Hairy Hawkbit	*Leontodon taraxacoides subsp. taraxacoides*	*1990*	DELWP (2016)
Hogweed	*Polygonum aviculare*	*Unknown*	NCCMA (2015)
Horehound	*Marrubium vulgare*	*2007*	Ecos (2007)
Kikuyu	*Pennisetum clandestinum*	*2001*	SKM (2001)
Little Medic	*Medicago minima*	*Unknown*	NCCMA (2015)
London Rocket	*Sisymbrium irio*	*2007*	Ecos (2007)
Madrid Brome	*Bromus madritensis*	*2007*	Ecos (2007)
Medic	*Medicago spp.*	*1990*	DELWP (2016)
Oat	*Avena sp.*	*Unknown*	NCCMA (2015)
Ox-tongue	*Helminthotheca ericoides*	*2007*	Ecos (2007)
Pampas Grass	*Cortaderia sp.*	*Unknown*	NCCMA (2015)
Paradoxical Canary-grass	*Phalaris paradoxa*	*1993*	DELWP (2016)
Pepper Tree	*Schinus mollee*	*Unknown*	NCCMA (2015)
Perennial Rye-grass	*Lolium perenne*	*1993*	DELWP (2016)
Poplar	*Populus sp.*	*2001*	SKM (2001)
Poppy	*Papaver sp.*	*Unknown*	NCCMA (2015)
Prickly Lettuce	*Lactuca serriola*	*2007*	Ecos (2007)
Prickly Sow-thistle	*Sonchus asper*	*2007*	Ecos (2007)
Ratís Tail Fescue	*Vulpia myuros*	*2007*	Ecos (2007)
Red Brome	*Bromus rubens*	*2007*	Ecos (2007)
Red Sand-spurrey	*Spergularia rubra*	*Unknown*	NCCMA (2015)
Red-stem Goosefoot	*Chenopodium macrospermum*	*2001*	DELWP (2016)
Rough Sow-thistle	*Sonchus asper s.l.*	*1990*	DELWP (2016)
Rye-grass	*Lolium sp.*	*Unknown*	NCCMA (2015)
Sea Barley-grass	*Hordeum marinum*	*Unknown*	NCCMA (2015)
Skeleton Weed	*Chondrilla juncea*	*1990*	DELWP (2016)
Small-flower Mallow	*Malva parviflora*	*Unknown*	NCCMA (2015)
Soft Brome	*Bromus hordeaceus subsp. hordeaceus*	*1993*	DELWP (2016)
Spear Thistle	*Cirsium vulgare*	*2007*	Ecos (2007)
Squirrel-tail Fescue	*Vulpia bromoides*	*1990*	DELWP (2016)
Strawberry Clover	*Trifolium fragiferum var. fragiferum*	*1993*	DELWP (2016)
Subterranean Clover	*Trifolium subulatus*	*2007*	Ecos (2007)
Tall Mallow	*Malva sylvestris var. sylvestris*	*Unknown*	NCCMA (2015)
Tamarisk	*Tamarix ramosissima*	*Unknown*	NCCMA (2015)
Toowoomba Canary-grass	*Phalaris aquatica*	*Unknown*	NCCMA (2015)

Common name	Scientific name	Date of last record	Source
Variegated Thistle	*Silybum marianum*	*Unknown*	NCCMA (2015)
Vetch	*Vicia sp.*	*2001*	SKM (2001)
Weld	*Reseda luteola*	*Unknown*	NCCMA (2015)
Wild Oat	*Avena fatua*	*2007*	Ecos (2007)
Willow-leaf Lettuce	*Lactuca saligna*	*2007*	Ecos (2007)
Wimmera Rye-grass	*Lolium rigidum*	*2007*	Ecos (2007)
Woolly Clover	*Trifolium tomentosum var. tomentosum*	*Unknown*	NCCMA (2015)

Appendix 4. Ecological Vegetation Class Mapping




Lake Leaghur
Contours and Vegetation
Legend
Parcel
Lake Leaghur Contours
ELEVATION
1.0m
0.5m
0.1m
Watercourse
River
Stream
Channel
Connector
Roads
Freeway
Highway
Major Road
Arterial Road
Road
Residential Street
Track
Vegetation - MDFRC 2009
Exotic
Poppies
Pampas Grass
Tamarisk
Prickly Lettuce
Annual grass and Thistle
African Boxthorn
Native
Scattered Lignum
Dead Cumbungi
Alive Cumbungi (part of Tall Marsh EVC 821)
Spike Sedge and Rushes (EVC 819 Spike Sedge Wetland)
Salt Club-sedge (EVC 308 Aquatic Sedgeland)
Red Gum Swamp (EVC 292)
River Red Gum regeneration
Infrastructure
Channel outfall
Outlet and Offtake points
1:6,000
The State of Victoria does not warrant the accuracy or completeness of information in this publication and any person using or relying upon such information does so on the basis that the State of Victoria shall bear no responsibility or liability whatsoever for any errors, faults, defects or omissions in the information.
Victoria
The Place To Be
NORTH CENTRAL
Catchment Management Authority
STRINGERS LANE
CANARY ISLAND-LEAGHUR ROAD

Appendix 5. Community and stakeholder engagement

Initial community consultation was undertaken for the Environmental Watering Plan in 2010, which captured information provided by members of the community, interest groups and agency stakeholders. Further consultation for the Lake Leaghur EWMP was undertaken via phone consultation with available community members that were originally consulted as part of the EWP to discuss the proposed watering regime, and update ecological values and objectives. As the original EWP was written prior to the floods, consultation focused on changes that were observed at the wetland during the floods and in the years since. The following section is the information captured from the consultation for the development of the EWP in 2010.

Community Engagement purpose

An important component of the EWPs involves identifying the goal, underlying environmental objectives and wetland type for each of the wetlands being assessed for the NVIRP. This requires an understanding of physical attributes, the history and the main biological processes associated with each of the wetlands.

In many cases adjoining landholders have had a long association with a wetland and have developed a good understanding that is useful to include in the development of the EWPs. This is particularly important if only limited monitoring records exist.

Method

A targeted community/agency engagement process was developed for the first round of EWPs developed in early 2009. A list of people with a good technical understanding of the wetland was developed by the technical working group (DPI, DSE and North Central CMA representatives).

This list included key adjoining landholders that have had a long association with the wetland and proven interest in maintaining its environmental value. A minimum of 2 landholders were invited to provide input for each wetland.

Other community and agency people that can provide useful technical and historic information include G-MW water bailiffs, duck hunters (Field & Game Association), bird observers and field naturalists. These people often possess valuable information across several of the wetlands currently being studied.

The method of obtaining information was informal and occurred at the wetland (e.g. oral histories, interviews). The information has been captured in brief dot point form and only technical information and observations are to be noted that will add value to the development of the EWP.

A list of participants has been recorded however all the comments have been combined for each of the wetlands so individual comments are not referenced back to individuals.

List of community and agency participants (Lake Leaghur)

- Laurence Cameron (G-MW)
- Ian Lanyon (landholder)
- Murray Lanyon (landholder)
- Graham Lehmann (landholder)
- Paul Haw (community member)
- Rod Stringer (community member)
- Ken Buchanan (landholder)
- Ron Bramley (Manager of Tony Sawer's farm)

Note: the results below document the comments received from the community members approached as part of the community engagement process. However, if new information comes to light this can be amended and redistributed accordingly.

Information provided to the community

It is important that the people approached for this information have a brief, straight summary of the purpose of the EWPs and type of information that will be useful to include in the planning process. Refer to summary below (adapted from Rob O'Brien, DPI 2009):

We are currently completing a study for NVIRP Northern Victoria Irrigation Renewal Project. It involves completing plans for Lake Leaghur, McDonalds Swamp, Little Lake Meran, Lake Meran, Little Lake Boort, Round Lake and Lake Yando.

As part of this it would be valuable to gather information that is broadly described below with a focus on the water regime and associated wetland values. It's recognised that these wetlands have been altered significantly since European settlement and the expansion of irrigated agriculture.

Providing information on these changes and how these influenced and altered the wetlands is important. It is particularly important to collate information or observations over more recent times, such as the last 30 - 50 years.

- *What was the original (pre-European settlement) condition of the wetland, including any details of the water regime and values (environmental, cultural)?*
- *What broad changes to the wetlands have occurred, particularly changed water regimes, as agricultural development influenced the floodplains and wetland?*
- *What connection does the wetland have to the floodplain to provide floodwater, or local catchment runoff?*
- *To what extent does the current irrigation supply channel have on the water regime over time?*
- *During more recent times (last 50yrs?) how did the productivity of the wetland vary with the altered water regimes?*
- *Describe the health of the wetland and notable plants and animals (both aquatic/terrestrial) associated with its water management.*
- *Comment on pest plants (boxthorn, willows, cumbungi etc)*
- *What influence has grazing domestic stock had on the reserve, both positive and negative effects?*
- *Given the history and current condition what type of water regime would be needed to achieve the best environmental results for the wetland?*
- *What other management practices could be adopted to improve the environmental value of the wetland?*

Comments and feedback from participants for original Lake Leaghur community and stakeholder engagement for the EWP.

- Lake Leaghur is the first wetland to fill after the occurrence of a Loddon Flood
- It historically had the best duck hunting in the region (with approximately 500 shooters observed out at the lake)
- It was a "pristine" lake due to it being periodically flushed from Loddon flood flows. It was considered to have crystal clear water.
- Ribbon weed grew around the edges of the lake as well as Twiggy Lignum.
- There was a natural predator of Cumbungi that ensured it never threatened the wetland with encroachment. It was also too deep (about 8ft when at the sill height).

• Vegetation at the southern end of the lake is of high value (e.g. Sea eagles and Black Coots). There was a fire here back in the 1990s but it was never a major threat.

• When it was full it used to back up into the trees at the south of the wetland.

• There used to be a weir in Wandella Creek.

• The Leaghur State Park has not been grazed for around 15 years. It is changing to dryland plants. You would need a 12/13ft flood for 10 days to get through the park.

• Great lake to observe birdlife (open water). Used to support countless thousands of Ibis. Teal and Musk Ducks were also remembered to occur in great numbers.

• The lake used to, and still supports, carpet pythons.

• Fish species that lake was known to support include: Redfin, Tench, Yellow Belly, River Blackfish and Eels

• The introduction of Common Carp, murky water from the channel system and increased salinity levels due to the lack of flooding changed the ecology of the lake. The lake depended on irrigation outfalls in response to water level dropping (evaporation).

• The Venebles Creek (which feeds into the Lake) use to run twice a year (July and October/November) and was generally wet all summer.

• In 1996 locals could not access the surrounding landscape because it was too wet, except for approximately 2-3 months.

• We use to have to travel to the school bus stop by boat (1970s)

• At one stage the only way I could access my house was by using a tractor

• Boort West of Loddon Salinity Management Plan lowered the sill level of the lake (actioned in November 1996). Aboriginal cooking mounds indicated the level for the concrete sill.

• Loddon Floods are seen as the best way to fill the lake, this will provide opportunities for regeneration of River Red Gums (the lake use to be covered with River Red Gums). Putting environmental flows may be required to maintain values through dry spells. There was agreement on an overall 1 in 3/5 year water regime.

• Trees near the outfall currently look in healthy condition

• The reeds and rushes need water every 5-6 years

• The lake needs a drying cycle

• In the 70s the lake received good wetting cycles with bigger floods flush the lake in between.

• The last wetting cycle for the lake only reach 1/3 full and the lake was full of Carp

• Carp exclusion is essential for the management of the lake

• Foxes are probably the biggest pest for this area. You don't see a lot of rabbits in the area, however there are more hares in recent times.

• The watertable and salt levels have dropped substantially due to the drought.

• At full flood level, Lake Leaghur seeps like a sieve

• The land use around Lake Leaghur use to be predominantly stocking country (covered in lignum), which has changed to intensive agriculture (tomato country).

• There is no local catchment for the lake (confirming Graham Hall's statement). Runoff contributes very little to the water balance of the wetland.

• There was a general discussion about Little Lake Boort:

- The value of this Lake to the surrounding community (social and economic)
- Great education tool for the community in improving the health of the lake
- Tourist attraction
- Discussion on how the community can secure water for the Lake

Please note: these issues will be addressed further in the development of the Little Lake Boort EWP

Additional comments, feedback and information from the 2016 EWMP community consultation:

- Lake Leaghur is an important site for Aboriginal artifacts and cooking mounds
- In the recent dry phase the lake bed supported some native species such as *Persecaria* sp; Red gum regenerated around the margins
- Lake leaghur is important because of the large tracts of surrounding native vegetation
- Fauna includes 5-6 species of frogs, long-necked turtles; goannas, black wallabies; and sea-eagles during flooding
- Flooding from the Loddon River via Venebles and Wandella Creeks provides a valuable source of River Red Gum and water-plant seeds
- Lake Leaghur has a low water table
- The lake supports Swamp buttercup and Twiggy lignum at the southern end
- Lake leaghur previously supported beds of ribbon weeds and clear water until the carp arrived in the 1970s
- Historically, redfin, tench, freshwater catfish, Murray cod occupied the lake
- New Year's Day at Leaghur was a big event, with boating and water skiing. There used to be a wooden boat ramp and shelter sheds.
- The land around Leaghur was purchased off farmers as a State Game Reserve
- The lake provides important habitat for waterbirds to feed and breed
- Timing of watering should be considered in light of bird flightpaths and the wet/dry phases of other wetlands in the district including Big Lake Boort, Lyndger, Yando, Murphies and Woolshed.

Appendix 6. Assessment against the Murray Darling Basin Plan Criteria for Identifying an Environmental Asset

Item	Criteria	Meets criteria	Justification
Criterion 1: The water-dependent ecosystem is formally recognised in international agreements or, with environmental watering, is capable of species listed in those agreements			
1	Assessment indicator: A water-dependent ecosystem is an environmental asset that requires environmental watering if it is:		
	(a) a declared Ramsar wetland; or		
	(b) with environmental watering, capable of supporting a species listed in or under the JAMBA, CAMBA, ROKAMBA or the Bonn Convention.	✓	Refer to Sixty-three water dependent fauna species have been recorded at Lake Leaghur, 53 are water bird species. The high productivity, depth and vegetation types (e.g. Swamp and Tall Marsh) at Lake Leaghur make it important site for waterbird feeding, and breeding. It has previously provided important breeding habitat for colonially waterbirds (e.g. Little Pied Cormorant, *Phalacrocorax melanoleucos;* Great Egret, *Ard* (DCE 1991), and 20 significant waterbird species have been previously recorded at the l Table 7). During drawdown, the wetland supports large numbers of feeding waterbirds 13).  **Figure 13 Waterbirds feeding during the drying phase at Lake Leaghur in 2014** While Freshwater Catfish (*Tandanus tandanus*; protected by the FFG Act) was recorded wetland in 1957 (

Item	Criteria	Meets criteria	Justification
			Table 7), this species is unlikely to return to the wetland without being translocated. La Leaghur has also in the past supported Eastern Long-necked Turtle (*Chelodina longicolli* Water Rat (*Hydromys chrysogaster*). Table 7, Lake Leaghur has supported species listed under all of the international agreements – JAMB ROKAMBA or the Bonn Convention
Criterion 2: The water-dependent ecosystem is natural or near-natural, rare or unique			
2	Assessment indicator: A water-dependent ecosystem is an environmental asset that requires environmental watering if it:		
	(a) represents a natural or near-natural example of a particular type of water-dependent ecosystem as evidenced by a relative lack of post-1788 human induced hydrologic disturbance or adverse impacts on ecological character; or		
	(b) represents the only example of a particular type of water-dependent ecosystem in the Murray-Darling Basin; or		
	(c) represents a rare example of a particular type of water-dependent ecosystem in the Murray-Darling Basin.		
Criterion 3: The water-dependent ecosystem provides vital habitat			
3	Assessment indicator: A water-dependent ecosystem is an environmental asset that requires environmental watering if it:		
	(a) provides vital habitat, including: (i) a refuge for native water-dependent biota during dry spells and	✓	Lake Leaghur provides a valuable drought refuge function when conditions are dry and has supported waterbird species during a previous environmental water delivery.

Item	Criteria	Meets criteria	Justification
	drought; or		
	(ii) pathways for the dispersal, migration and movements of native water-dependent biota; or		
	(iii) important feeding, breeding and nursery sites for native water-dependent biota; or	✓	Lake Leaghur provides is important breeding site for waterbirds
	(b) is essential for maintaining, and preventing declines of, native water-dependent biota.	✓	Lake Leaghur provides important habitat for water dependent fauna in the area, particularly waterbirds
Criterion 4: Water-dependent ecosystems that support Commonwealth, State or Territory listed threatened species or communities			
4	Assessment indicator: A water-dependent ecosystem is an environmental asset that requires environmental watering if it:		
	(a) supports a listed threatened ecological community or listed threatened species; or Note: See the definitions of ***listed threatened ecological community*** and ***listed threatened species*** in section 1.07. (Listed under the EPBC Act 1999)	✓	Lake Leaghur has been known to support two nationally threatened species : Striped Legless Lizard and Sw
	(b) supports water-dependent ecosystems	✓	Lake Legahur supports one endangered and three vulnerable EVCs within the Victorian Riverine Bioregion.

Item	Criteria	Meets criteria	Justification
	treated as threatened or endangered (however described) under State or Territory law; or		
	(c) supports one or more native water-dependent species treated as threatened or endangered (however described) under State or Territory law.	✓	Lake Leaghur supports 15 state listed waterbird species.
Criterion 5: The water-dependent ecosystem supports, or with environmental watering is capable of supporting, significant biodiversity			
5	Assessment indicator: A water-dependent ecosystem is an environmental asset that requires environmental watering if it suppor environmental watering is capable of supporting, significant biological diversity. This includes a water-dependent ecosystem that:		
	(a) supports, or with environmental watering is capable of supporting, significant numbers of individuals of native water-dependent species; or		
	(b) supports, or with environmental watering is capable of supporting, significant levels of native biodiversity at the genus or family taxonomic level, or at the ecological community level.		

Appendix 7. Criteria and assessment indicators for Lake Leaghur ecosystem functions

Item	Criteria	Meets criteria	Description for Lake Leaghur
Criterion 1: The ecosystem function supports the creation and maintenance of vital habitats and populations			
1	**Assessment indicator:** An ecosystem function requires environmental watering to sustain it if it provides vital habitat including:		
	(a) a refugium for native water-dependent biota during dry periods and drought; or	✓	Waterbirds would opportunistically use Lake Leaghur as a feeding site if in a wet phase.
	(b) pathways for the dispersal, migration and movement of native water-dependent biota; or	✓	During natural floods, Lake Leaghur provides a conduit for native water dependent biota from the Loddon River to the Meran Lakes complex
	(c) a diversity of important feeding, breeding and nursery sites for native water-dependent biota; or	✓	Lake Leaghuir provides diverse habitats that support a range of waterbirds.
	(d) a diversity of aquatic environments including pools, rifle and run environments; or	X	
	(e) a vital habitat that is essential for preventing the decline of native water-dependent biota.	X	
Criterion 2: The ecosystem function supports the transportation and dilution of nutrients, organic matter and sediment			
2	**Assessment indicator:** An ecosystem function requires environmental watering to sustain it if it provides for the transportation and dilution of nutrients, organic matter and sediment, including:		
	(a) pathways for the dispersal and movement of organic and inorganic sediment, delivery to downstream reaches and to the ocean, and to and from the floodplain; or	X	
	(b) the dilution of carbon and nutrients from the floodplain to the river systems.	X	
Criterion 3: The ecosystem function provides connections along a watercourse (longitudinal connections)			
3	**Assessment indicator:** An ecosystem function requires environmental watering to sustain it if it provides connections along a watercourse or to the ocean, including longitudinal connections:		
	(a) for dispersal and re-colonisation of native water-dependent communities; or	X	
	(b) for migration to fulfil requirements of life history stages; or	X	
	(c) For in-stream primary production.	X	

Item	Criteria	Meets criteria	Description for Lake Leaghur
Criterion 4: The ecosystem function provides connections across floodplains, adjacent wetlands and billabongs (lateral connections)			
4	**Assessment indicator:** An ecosystem function requires environmental watering to sustain it if it provides connections across floodplains, adjacent wetlands and billabongs, including:		
	(a) lateral connections for foraging, migration and re-colonisation of native water-dependent species and communities; or	X	
	(b) lateral connections for off-stream primary production.	X	