LAKE YANDO

ENVIRONMENTAL WATERING PLAN

NORTH CENTRAL
Catchment Management Authority
Connecting Rivers, Landscapes, People

PREPARED FOR THE
NORTHERN VICTORIA IRRIGATION RENEWAL PROJECT

NVIRP

June 2010

DOCUMENT HISTORY AND STATUS

Version	Date Issued	Prepared By	Reviewed By	Date Approved
Version 1	25 March 2010	Rebecca Lillie, Michelle Bills, Emer Campbell	Emer Campbell	26 March 2010
Version 2	31 March 2010	Rebecca Lillie, Michelle Bills and Emer Campbell	NVIRP TAC	7 April 2010
Version 3	14 April 2010	Rebecca Lillie, Michelle Bills and Emer Campbell	ERP	27 April 2010
Version 4	7 May 2010	Rebecca Lillie, Michelle Bills and Emer Campbell	ERP	13 May 2010
Version 5	18 May 2010	Rebecca Lillie, Michelle Bills and Emer Campbell	ERP	18 May 2010
Version 6	21 May 2010	Rebecca Lillie, Michelle Bills and Emer Campbell	NVIRP, ERP	28 May 2010
Version 7	28 May 2010	Rebecca Lillie, Michelle Bills and Emer Campbell	NVIRP, ERP	28 May 2010
Version 8	4 June 2010	Rebecca Lillie, Michelle Bills and Emer Campbell	NVIRP	4 June 2010

DISTRIBUTION

Version	Date	Quantity	Issued To
Version 1	25 March 2010	Internal review	Emer Campbell
Version 2	31 March 2010	Email	NVIRP TAC
Version 3	14 April 2010	Email	ERP
Version 4	7 May 2010	Email	ERP
Version 5	18 May 2010	Email	ERP
Version 6	21 May 2010	Email	NVIRP, ERP
Version 7	28 May 2010	Email	NVIRP, ERP
Version 8	4 June 2010	Email	NVIRP, ERP

DOCUMENT MANAGEMENT

Printed:	4 June 2010
Last saved:	4 June 2010 11:25 AM
File name:	NCCMA-37795 – Lake Yando EWP_V8
Authors:	Rebecca Lillie, Michelle Bills and Emer Campbell
Name of organisation:	North Central CMA
Name of document:	Lake Yando Environmental Watering Plan
Document version:	Final, Version 8
Document manager:	37795

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 5440 1800
F: 03 5448 7148
E: info@nccma.vic.gov.au
www.nccma.vic.gov.au

Front cover photo: Lake Yando 2009, North Central CMA

The Lake Yando Environmental Watering Plan is a working document, compiled from the best available information. It will be subject to revision in the future as new information becomes available.

Please cite this document as: NCCMA (2010). *Lake Yando Environmental Watering Plan,* Prepared for the Northern Victorian Irrigation Renewal Project, North Central Catchment Management Authority, Huntly, Victoria.

EXECUTIVE SUMMARY

The Lake Yando Environmental Watering Plan (EWP) documents the approach to mitigating the potential impacts of the Northern Victoria Irrigation Renewal Project (NVIRP) due to significant reductions in channel outfalls to the wetland.

The following components are the primary means by which the commitment of no net environmental loss for Lake Yando will be achieved for the NVIRP project. The main conclusions are summarised below.

Defining the environmental values of Lake Yando
Lake Yando is a bioregionally important wetland occupying 78 ha of an 86 ha Wildlife Reserve. It is of bioregional conservation significance largely as it continues to support Red Gum Swamp (EVC 292) vegetation and the diversity of fauna species it supports.

Part of the Murray Flora and Fauna Bulk Entitlement has recently been used at Lake Yando to provide drought refuge for a variety of fauna species, as well as avoiding declining health of Red Gum Swamp vegetation within the Boort district.

A water management goal has been developed in light of the current condition of Lake Yando, the values the wetland supports and potential risk factors that need to be managed.

Lake Yando water management goal:
To provide a water regime typical of a deep freshwater marsh that supports the maintenance and recruitment of River Red Gums (*Eucalyptus camaldulensis*) and promotes the growth of a diverse range of aquatic and amphibious plant species offering a variety of habitats to waterbirds, reptiles and amphibians.

Defining the water required to protect the environmental values
A number of ecological objectives are identified and are based on historic and current wetland condition, and water dependent environmental values (habitat, species/communities and processes). The hydrological requirements for each of these objectives were identified, and a desired water regime required to achieve the water management goal is described.

Wetland water regime:
Fill Lake Yando to full supply level (87.59 m AHD) to inundate River Red Gum Swamp (EVC 292) community one in three years for approximately five months allowing for natural draw-down.

Top-ups may be required to extend the duration depending on waterbird breeding. Push water into Black Box (*Eucalyptus largiflorens*) and Tangled Lignum (*Muehlenbeckia florulenta*) communities (Riverine Chenopod Woodland: EVC 103) one in six years (87.8 m AHD); ensure these communities are not inundated for more than three months. Allow majority of wetland to dry between watering events. Gilgai depressions may stay damp or retain water between floods.

The volumes of water required to provide the desired water regime for Lake Yando have been assessed using a simplified version of the Savings at Wetlands from Evapotranspiration daily Time-Series (SWET) model.

The total volume required to fill Lake Yando to FSL (87.59 m) one in three years, and one in six to 87.8 m AHD, to inundate the Riverine Chenopod Woodland vegetation is 863 ML. The maximum volume ever likely to be required over any 12 month period (95th percentile mean annual volume) is 904 ML.

Assessment of mitigation water requirement
Mitigation water is defined as the volume of water required to ensure no net impacts on high environmental values resulting from NVIRP.

The assessment of the requirement for mitigation water for Lake Yando demonstrates that **mitigation water is not required to maintain the environmental values of the wetland.** Calculations indicate that losses in the baseline year (2004/05) did not contribute to the wetlands surface water balance and therefore did not directly benefit the environmental values displayed at Lake Yando.

Potential risks, limiting factors and adverse impacts associated with the desired water regime

A number of potential risks, limiting factors and adverse impacts are identified that may result from the provision of mitigation water as a portion of the desired water regime. An adjoining landholder currently has a diversion licence permitting the opportunistic extraction of 120 ML from Lake Yando. The conditions of this licence threaten the achievement of the water management goal and associated objectives. It is recommended that alternative supply options are investigated and the licence conditions are reviewed.

Infrastructure requirements

Recent infrastructure upgrades have enabled Lake Yando to be filled at a rate of 35 ML/day (capacity of the delivery channel) while the automated regulator has a maximum capacity of 60 ML/day. At a rate of 35 ML/day, Lake Yando can be filled in 14 days (assuming no losses and adequate capacity is available in channel 5/2). The current delivery infrastructure is considered adequate to deliver the desired water regime and no infrastructure upgrades are recommended as part of NVIRP.

Adaptive management framework

An adaptive management approach (assess, design, implement, monitor, review and adjust) is incorporated into the EWP to ensure that it is responsive to changing conditions.

The Lake Yando EWP has been developed using the best available information. However, a number of information and knowledge gaps are identified in the document which may impact recommendations and/or information presented. These knowledge gaps will be addressed as part of the adaptive management approach outlined within the EWP as additional information becomes available.

Governance arrangements

A summary of the roles and responsibilities (e.g. land manager, environmental water manager, and system operator) relating to the development and implementation of EWPs are defined. A framework for operational management has also been developed to describe the annual decision-making process required to coordinate the implementation of the desired water regime for Lake Yando.

CONTENTS PAGE

ACKNOWLEDGEMENTS

The information contained in the Lake Yando Environmental Watering Plan (EWP) has been sourced from a variety of reports and field inspections and from individual knowledge and expertise.

The North Central Catchment Management Authority (CMA) acknowledges the assistance of the following people in preparing this EWP.

- 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 (Department of Sustainability and Environment)
- Mark Tscharke (Parks Victoria)
- Ross Stanton and Lawrence Cameron (G-MW)
- Pat Feehan (Feehan Consulting)
- Ross Plunkett, Chris Solum and Mark Paganini (NVIRP)
- NVIRP Technical Advisory Committee (listed in Appendix A, Table A1)
- Wetland workshop attendees (listed in Appendix A, Table A2)
- Marg Piccoli (landholder), Rod Stringer (landholder)
- Paul Haw (community member)
- Graham Hall, Bridie Velik-Lord, Rebecca Horsburgh, Peter McRostie, Lyndall Rowley (North Central CMA).

ABBREVIATIONS

AAV	Aboriginal Affairs Victoria
AVW	Atlas of Victorian Wildlife
ANCA	Australian Nature Conservation Agency
AUSRIVAS	Australian River Assessment System
BE	Bulk Entitlement
BONN	Convention on the Conservation of Migratory Species of Wild Animals
CAMBA	China–Australia Migratory Bird Agreement
CMA	Catchment Management Authority
DCFL	Department of Conservation Forests and Lands
DEWHA	Department of the Environment, Water, Heritage and the Arts
DPCD	Department of Planning and Community Development
DPI	Department of Primary Industries
DSE	Department of Sustainability and Environment
EES	Environmental Effects Statement
EPBC	*Environment Protection and Biodiversity Conservation Act 1999*
ERP	Expert Review Panel
EVC	Ecological Vegetation Class
EWH	Environmental Water Holder
EWP	Environmental Watering Plan
FFG	*Flora and Fauna Guarantee Act 1988*
FIS	Flora Information System
FSL	Full Supply Level
GIS	Geographic Information Systems
GL	Gigalitre (one billion litres)
GMID	Goulburn Murray Irrigation District
G-MW	Goulburn–Murray Water
JAMBA	Japan–Australia Migratory Bird Agreement
LTCE	Long-term Cap Equivalent
MDFRC	Murray-Darling Freshwater Research Centre
MNES	Matters of National Environmental Significance
North Central CMA	North Central Catchment Management Authority
NVIRP	Northern Victoria Irrigation Renewal Project
ROKAMBA	Republic of Korea–Australia Migratory Bird Agreement
SEMP	Site Environmental Management Plan
SWET	Savings at Wetlands from Evapotranspiration daily Time-Series
TAC	Technical Advisory Committee
TIS	Torrumbarry Irrigation System
VEAC	Victorian Environmental Assessment Council
VROTS	Victorian Rare or Threatened Species

1. Northern Victoria Irrigation Renewal Project

The Northern Victoria Irrigation Renewal Project (NVIRP) is a $2 billion works program to upgrade ageing irrigation infrastructure across the Goulburn Murray Irrigation District (GMID) and to save water lost through leakage, seepage, evaporation and system inefficiencies. Works will include lining and automating channels, building pipelines and installing new, modern metering technology. These combined works will improve the irrigation system's delivery efficiency and recover a long term average (LTCE) of 425 GL of water per year.

The GMID uses a number of natural carriers, rivers, lakes and wetlands for both storage and conveyance of water. While the water savings generated are from 'losses' within the irrigation system, in some cases the losses from the pre-NVIRP operating regime provides incidental benefits to environmental assets (SKM 2008).

1.1. Decision under the Environmental Effects Act 1978

On the 14 April 2009, the Minister for Planning made a decision that an Environment Effects Statement (EES) was not required for the NVIRP project, although this decision was subject to several conditions (DPCD 2009). The conditions that apply to the protection of wetlands and waterways include:

Condition 3: *development of a framework for protection of aquatic and riparian ecological values through management of water allocations and flows within the modified GMID system to the satisfaction of the Minister of Water*

NVIRP have developed a Water Change Management Framework (NVIRP 2010) in response to this condition. The framework outlines the processes and methods for preparing Environmental Watering Plans to mitigate potential impacts on wetlands and waterways at risk from the implementation of the NVIRP through adaptive water management (NVIRP 2010).

Condition 5: *Environmental Watering Plans (EWPs) are required for 'at risk' waterways and wetlands before operation of the relevant NVIRP work commences*

1.2. Water Change Management Framework

The Water Change Management Framework (NVIRP 2010) sets out the overarching principles with respect to environmental management for the operation of the modified GMID. These principles include:

- NVIRP will strive for efficiency in both water supply and farm watering systems.
- NVIRP will design and construct the modernised GMID system to comply with environmental requirements as specified in the no-EES conditions.
- NVIRP will develop management and mitigation measures consistent with established environmental policies and programs in place in the GMID.
- Renewal or refurbishment of water infrastructure will be undertaken to the current best environmental practice, including any requirements to better provide environmental water. Best environmental practice will require irrigation infrastructure required to deliver environmental water to be retained (no rationalisation at these sites) or upgraded to allow for future use.
- Management and mitigation measures will be maintained into the future through establishment of or modification to operating protocols and operational arrangements.

In October 2008, the Food Bowl Modernisation Project Environmental Referrals Report (SKM 2008) assessed Stage 1 (upgrade of the backbone and connections) of the NVIRP in relation to operational impacts on waterways, wetlands and regional groundwater from increased system efficiencies such as changes in channel outfalls, delivery patterns and reductions in leakage and seepage.

SKM (2008) prioritised 10 wetlands and four rivers with significant environmental values that may be impacted by NVIRP, particularly by significant reductions in channel outfalls across the GMID.

The 10 wetlands are:

- Lake Elizabeth
- Lake Murphy
- Johnson Swamp
- McDonalds Swamp
- Round Lake
- Lake Meran
- Little Lake Meran
- Lake Leaghur
- Lake Yando
- Little Lake Boort

The above wetlands are located within the North Central CMA region and require the development of an EWP. The Johnson Swamp EWP, and Interim Lake Murphy and Lake Elizabeth EWPs were completed prior to the operation of NVIRP works in the 2009-2010 irrigation season.

While NVIRP has been established to implement the modernised works, it will have no ongoing role in the operation of the modified GMID or environmental management in the region. Therefore, NVIRP will need to establish effective management arrangements to ensure that any management or mitigation measures are implemented on an ongoing basis, particularly in the EWPs (NVIRP 2010).

1.3. Purpose and scope of Environmental Watering Plans

The EWPs are the primary means by which the commitment of no net environmental loss will be achieved for water savings projects (NVIRP 2010). Each EWP will:

- identify environmental values of the wetland
- identify the water required to protect the environmental values
- define the environmental watering regime and the sources of water
- identify if there is a need to provide mitigation water and, if so, determine the quantification of mitigation water
- identify the infrastructure requirements
- identify mitigation measures to minimise the potential risks and impacts associated with the provision of mitigation water
- draft protocols for ongoing water supply
- outline governance arrangements.

This EWP is not a wetland management plan, therefore it is not intended to provide management guidance for wetlands; rather it is aimed at providing a water supply protocol that can be agreed upon by the land, water and catchment managers.

NVIRP is responsible for managing and mitigating the significant environmental effects of its own activities. It is not responsible for managing and mitigating the effects of other activities or circumstances. NVIRP is not responsible for managing and mitigating the environmental effects of activities or circumstances beyond its control such as:

- reduced outfalls due to Government policy initiatives
- water trade
- drought and climate change
- management and modernisation programs carried out by others (NVIRP 2010).

1.4. Development process

The Lake Yando EWP was developed in collaboration with key stakeholders including G-MW, NVIRP, the Department of Sustainability and Environment (DSE), Parks Victoria and the Department of Primary Industries (DPI) according to the process outlined in Figure 1. A number of tasks were undertaken to develop the EWP, as follows:

- scoping and collating information
- defining ecological objectives and associated water requirements

- identifying risks and threats
- assessing infrastructure requirements
- identifying the need to provide mitigation water and, if needed, determine the quantification of mitigation water
- developing recommendations on governance arrangements and adaptive management
- consulting and engaging stakeholders and adjacent landholders.

Following development, EWPs will be reviewed by the DSE Approvals Working Group (membership comprised of departmental representatives) and the Expert Review Panel (ERP) prior to consideration by the Minister for Water.

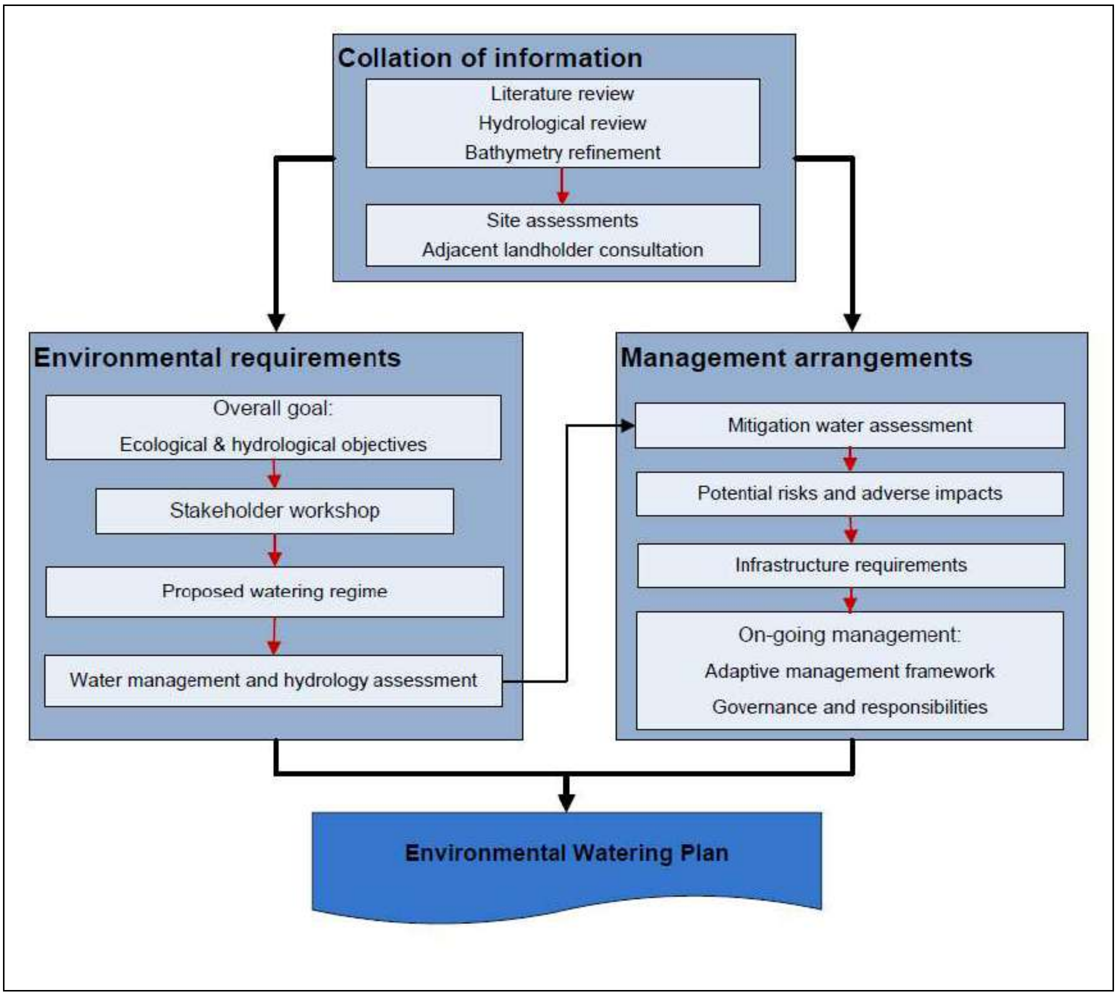


Figure 1: EWP development process

1.4.1. Consultation and engagement

To assist in collating information for the Lake Yando EWP, a targeted community and agency engagement process was undertaken. Key groups consulted were the NVIRP Technical Advisory Committee (TAC), agency stakeholders, interest groups and adjoining landholders. An outline of the various groups' involvement is provided below.

The TAC was convened by the NVIRP to oversee the development of the EWPs to ensure quality, completeness and practicality. The committee included representation from CMAs, G-MW, DPI, NVIRP and DSE (Appendix A). A content template for the EWPs was developed and approved by the TAC.

A workshop was held on 25 February 2010 with key stakeholders and experts (Appendix A) in order to discuss and refine the water management goal, ecological objectives, and water requirements for Lake Yando.

Consultation was also undertaken with adjoining landholders who have had a long association with the wetland and proven interest in maintaining its environmental value. Other community and agency people were directly engaged to provide technical and historic information, including community members and G-MW staff. A summary of the information sourced from this process is provided in Appendix B.

2. Lake Yando

Lake Yando is situated approximately 9 km north of Boort and 3.8 km west of the Loddon River (Figure 2). It is located in the Wandella Creek sub-catchment of the Loddon River basin. It is of bioregional conservation significance (NLWRA, cited in NCCMA 2005) largely as it continues to support Red Gum Swamp (EVC 292) vegetation and due to the diversity of fauna species it supports.

Lake Yando occupies 78 ha of an 86 ha Wildlife Reserve (DSE 2009a). It is oval in shape with an irregular floor which reflects a gilgai surface. The wetland is deeper on the eastern side, with a lowest elevation at 86.4 m AHD. With a full supply level (FSL) at 87.59 m AHD, the wetland has a storage capacity of 478 ML and a maximum depth of 1.2 m (Price Merrett Consulting 2006).

Refer to Appendix C for the contour plan prepared for Lake Yando by Price Merrett Consulting (2006).

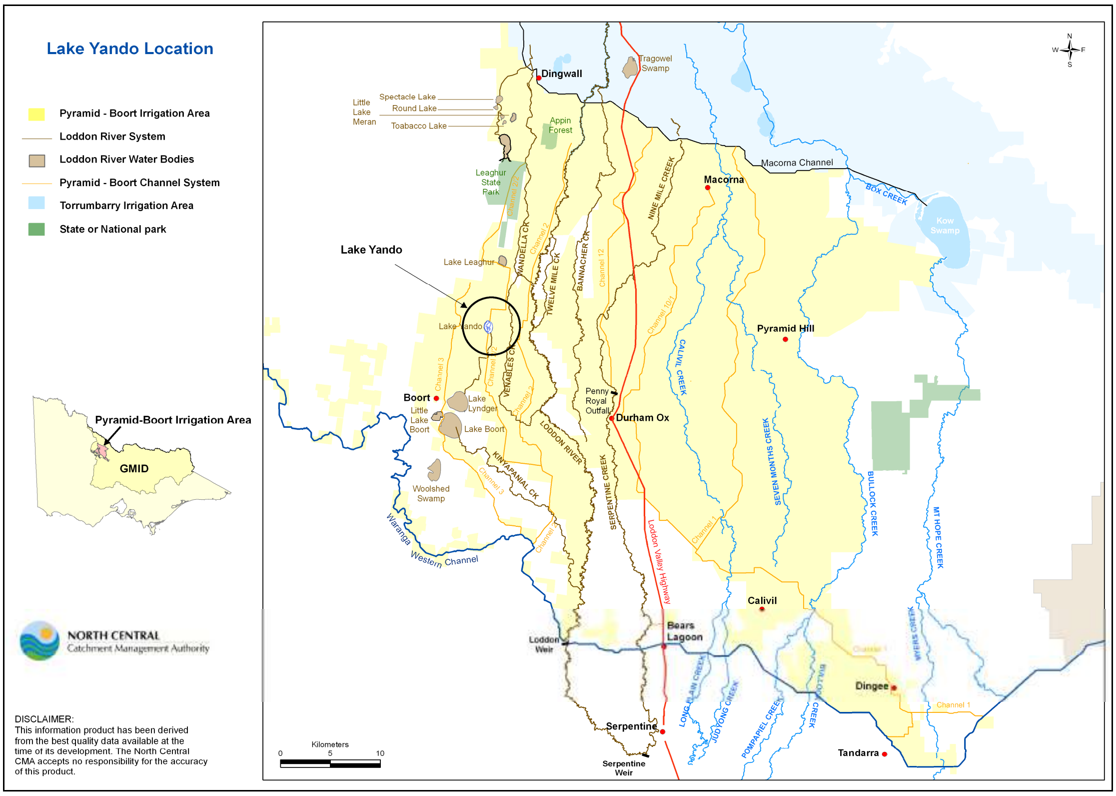


Figure 2: Location of Lake Yando

2.1. Wetland context and current condition

Prior to European settlement, Lake Yando was a deep freshwater marsh[1] dominated by River Red Gums (*Eucalyptus camaldulensis*) (DSE 2009b). Anecdotal evidence suggests that trees were widely spaced across the wetland floor (Appendix B). It would naturally have received floodwaters from an unnamed distributary of Venables Creek and, in years of larger floods, would have received water from Kinypanial Creek via Lake Boort and Lake Lyndger (Appendix B). Lake Yando was well connected to a creek and floodplain system where wide corridors of native vegetation provided opportunity for native fauna to move throughout the floodplain area (Appendix B). The natural catchment area of Lake Yando was quite large. During very wet periods water could runoff a large area south of the wetland, find its way into drainage lines and creeks, and flow towards Lake Yando (pers. comm. Rod Stringer [landholder] and Lawrence Cameron [G-MW] 25 March 2010).

European settlement, the establishment of the Pyramid-Boort Irrigation System in the 1920s/1930s, and construction of levees across the floodplain have resulted in significant

[1] Deep freshwater marshes are generally less than 2 m deep and are inundated for longer than eight months of the year (DCFL 1989)

changes to the hydrology of the wetland. It consequently experienced a more permanent water regime as a result of receiving significant volumes of channel outfall water and drainage water (further detail provided in Section 4). Farm development and the construction of roads, channels, levees etc. have significantly impacted the natural catchment and altered water flows into Lake Yando (pers. comm. Rod Stringer [landholder] and Lawrence Cameron [G-MW] 25 March 2010).

An assessment undertaken on 22 October 2009 (Campbell *et al*. 2009) reported the following main components:

- River Red Gum trees across the wetland displaying various stages of health. To the west of the wetland they are predominately dead (Plate 1); however to the east they have regenerated and are in moderate to good condition (Plate 2).
- River Red Gum trees are of mixed age, with some thick patches of younger trees, suggesting some level of recruitment (Plate 1).
- Understorey vegetation dominated by exotic annual grasses (Plate 1).
- A small patch of Tangled Lignum (*Muehlenbeckia florulenta*) towards the southeast corner of the wetland.
- Small patches of both Narrow-leaf and Broadleaf Cumbungi (*Typha domingensis* and *T. orientalis*) in the north-east.
- Small patches of herbs supported by damper ground, such as the rare Winged Water-starwort (*Callitriche umbonata*).

Unlike other wetlands within the district, Lake Yando continues to support River Red Gum Swamp (EVC 292) vegetation, dead standing and fallen timber, scattered reeds and, when inundated, open water and associated mudflats. These habitat components in turn attract a diversity of waterbirds, reptiles and amphibians (Section 3).

A summary of the wetland characteristics is provided in Appendix D.

Plate 1: Dead River Red Gums in the western section (Source: MDFRC 2009)

Plate 2: Healthy River Red Gums in the eastern section (Source: MDFRC 2009)

2.2. Catchment setting

Lake Yando is located within the Wandella Creek sub-catchment in the Victorian Riverina bioregion. A small local catchment area of 50 ha directs rainfall runoff into the creekline, then into the Lake Yando (pers. comm. Rod Stringer [landholder] and Lawrence Cameron [G-MW] 25 March 2010). The amount of water draining from the catchment depends upon climatic conditions, watertable height, surrounding land use (i.e. irrigated or dryland agriculture) and the amount and timing of the rain, etc. In this heavy clay floodplain area it would take a very high rainfall event to produce enough runoff to reach the wetland (i.e. 75 -100 mm).

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 temperatures range from 31.3℃ in January to 13.9℃ in July, with mean minimum temperatures falling below 5℃ between June and August (Bureau of Meteorology 2009).

Lake Yando is connected to the Pyramid-Boort Irrigation System and receives inflows from channel 5/2 (Figure 3). Following works completed in 2008, the delivery channel to Lake Yando and a portion of channel 5/2 have a capacity of 35 ML/day. The fully automated outfall structure has a reported capacity of 60 ML/day.

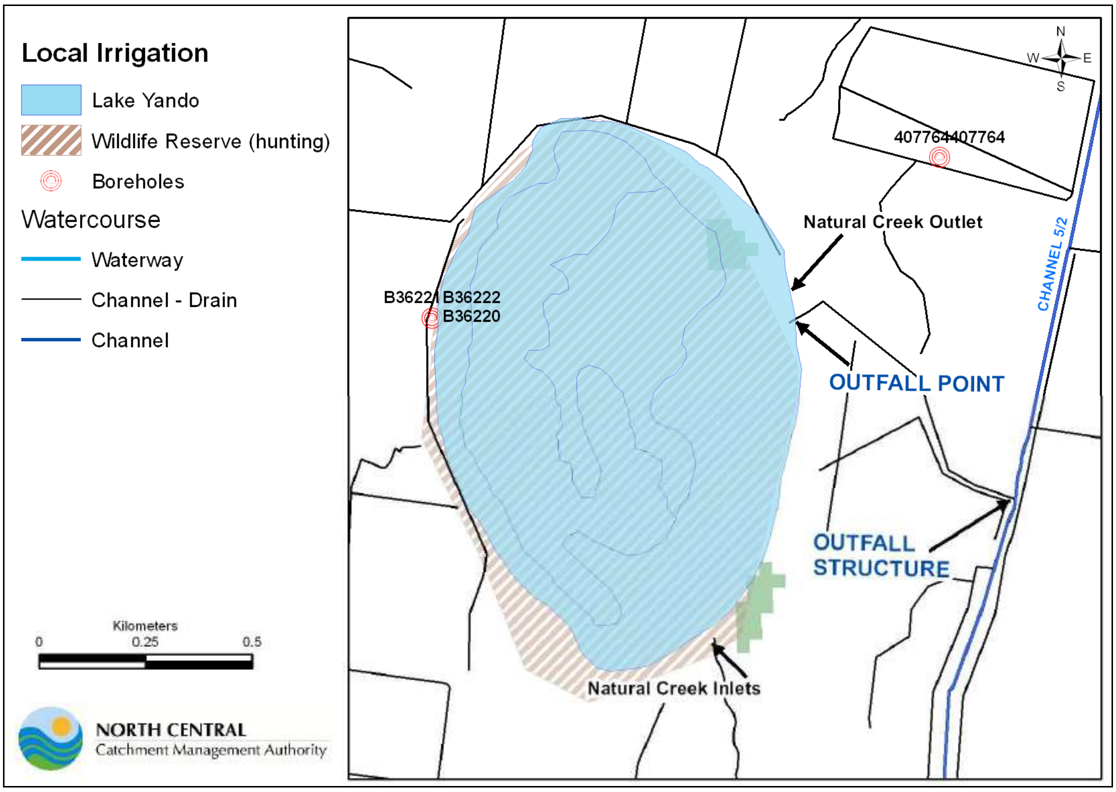


Figure 3: Inflow points at Lake Yando

2.3. Land status and management

Lake Yando is a State Wildlife Reserve under the *Crown Land (Reserves) Act 1978* and is managed by Parks Victoria under the *Wildlife Act 1975*. Wildlife reserves are managed primarily for the conservation of native wildlife but allow recreational and educational use so long as it does not conflict with the primary aim (LCC 1988).

In 2009, the Victorian government endorsed (with amendments) the Victorian Environment Assessment Council (VEAC) recommendations for public land management. Lake Yando will remain as a wildlife reserve under the "state game reserve" classification. A series of VEAC recommendations relating to the establishment of National Parks will take effect on 29 June 2010. However, the proclamation date for all other areas (wildlife reserves, nature conservation reserves, etc) is yet to be determined (pers. comm. Doug Hooley [DSE], 20 May 2010). Wildlife reserves will be managed to conserve and protect species, communities or habitats of indigenous animals and plants while permitting recreational (including hunting in season as specified by the land manager) and educational use (VEAC 2008 and DSE 2009c).

2.4. Cultural heritage

Cultural heritage values are abundant on productive wetlands throughout the district, including Lake Yando (pers. comm. Rob O'Brien [DPI], 8 February 2010). No sites are currently registered with Aboriginal Affairs Victoria (AAV); however anecdotal evidence suggests it was an extremely productive system that provided food and other resources to Aboriginal people (Appendix B).

2.5. Recreation

Unlike other wetlands in the Boort District (such as Lake Leaghur and Little Lake Boort), Lake Yando still supports Red Gum Swamp (EVC 292) vegetation. As such, it has not been as popular for some recreational activities including water skiing. However, it does support additional activities including:

- Hunting
- Bird watching
- Boating (i.e. row-boats and kayaks)
- 4WD and motorbikes.

2.6. Legislative and policy framework

2.6.1. International agreements

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

- Japan–Australia Migratory Bird Agreement (JAMBA)
- China–Australia Migratory Bird Agreement (CAMBA)
- Republic of Korea–Australia Migratory Bird Agreement (ROKAMBA)
- Convention on the Conservation of Migratory Species of Wild Animals (also known as the Bonn Convention).

Lake Yando is known to support species protected by each of the above international migratory bird agreements (Table 1). As wetland habitat for a number of protected species, Lake Yando is required to be protected and conserved in accordance with these international agreements (DEWHA 2009).

2.6.2. Federal legislation

The *Environment Protection and Biodiversity Conservation (EPBC) Act 1999* is the key piece of legislation pertaining to biodiversity conservation within Australia. It aims to control potential impacts on matters of national environmental significance (MNES)[2].

Lake Yando is known to support protected migratory waterbirds. In addition, two species listed under the *EPBC Act* have been recorded at Lake Yando (Table 1). Actions that may significantly impact any of these MNES are subject to assessment and approval by the Minister for the Environment, Heritage and the Arts. The NVIRP works program is also subject to assessment and approval under the *EPBC Act*.

2.6.3. State legislation

Flora and Fauna Guarantee (FFG) Act 1988

The *Flora and Fauna Guarantee (FFG) Act 1988* aims to protect a number of identified threatened species and communities within Victoria. Lake Yando is known to support a number of species both protected[3] and listed under the *FFG Act* (Table 1 and Table 3). Disturbance or collection of any of these threatened species will require a permit from the DSE.

Environmental Effects Act 1978

Potential environmental impacts of a proposed development are subject to assessment and approval under the *Environmental Effects Act 1978*. As such, the NVIRP works program and any associated environmental impacts are subject to assessment and approval under the Act (as discussed in Section 1.1).

Planning and Environment Act 1987

The removal or disturbance to native vegetation within Victoria is controlled by the implementation of a three-step process of avoidance, minimisation and offsetting under the *Planning and Environment Act 1987*. Any proposed removal or disturbance to native vegetation associated with the NVIRP works program will require the implementation of the three-step process, assessment and approval under the Act.

Water Act 1989

The Water Act 1989 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 as part of the Environmental Water Reserve. The Act provides a framework for defining and managing Victoria's water resources.

[2] There are seven MNES that are protected under the EPBC Act, these are: World Heritage properties, National Heritage places, wetlands of international importance, listed threatened species and ecological communities, migratory species protected under international agreements, Commonwealth marine areas, and nuclear actions (including uranium mines) (DEWHA 2009).

[3] Includes plant taxa belonging to families or genera protected by the Act (DSE 2009d).

Aboriginal Heritage Act 2006
All Aboriginal places, objects and human remains in Victoria are protected under the *Aboriginal Heritage Act 2006* (DPCD 2007). Although no sites are currently registered with AAV, Lake Yando is known to have been an extremely productive wetland that provided food and other resources to Aboriginal people (Section 2.4).

Other - Threatened Species Advisory Lists
Threatened species advisory lists for Victoria are maintained by the DSE and are based on technical information and advice obtained from a range of experts which are reviewed every one to two years. These advisory lists are not the same as the Threatened List established under the *FFG Act*. There are no legal requirements or consequences that flow from inclusion of a species in advisory lists. However, some of the species in these advisory lists are also listed as threatened under the *FFG Act*. Lake Yando is known to support flora and fauna species that are included on advisory lists (Table 1 and Table 3).

3. Lake Yando environmental values

The primary purpose of this EWP is to assess and advise on mitigating potential impacts on high environmental values supported by Lake Yando. While it is recognised that the wetland provides a number of broader ecological and landscape values (i.e. ecological processes, representativeness and distinctiveness in landscape), high environmental values have previously been defined by the conservation significance of the wetland or species at an international, national or state level (SKM 2008; NVIRP 2010).

As such, in describing the values supported by the wetland in the sections below, an emphasis is placed on identifying listed flora and fauna species, and vegetation communities followed by the broader ecological and landscape values. All listed values have been presented in this section with full species lists provided in Appendix E.

Lake Yando is a highly valued wetland due mainly to the diversity of habitats it provides, particularly Red Gum Swamp (EVC 292) vegetation and a variety of additional habitat types within an agricultural landscape. The bathymetry of the wetland contributes to providing a range of habitat types. For example, deeper channels along the eastern side create variable water depths and duration of inundation (Appendix B). This habitat diversity attracts a variety of fauna species including waterbirds, reptiles, amphibians and macroinvertebrates.

3.1. Fauna

As discussed in Section 2.1, Lake Yando supports a diverse array of habitat types including Red Gum Swamp (EVC 292) vegetation, open water and associated mudflats, scattered reeds, and dead standing and fallen timber which in turn support a range of fauna species.

The wetland is known to be extremely productive for waterbird use and breeding. Historically, thousands of ibis roosted and nested in Lake Yando when it was inundated (Appendix B). A variety of waterbirds were observed at the wetland in response to an environmental watering event in 2009. Species observed include: Yellow-billed Spoonbill (*Platalea flavipes*), Banded Stilt (*Cladorhynchus leucocephalus*), Australian White Ibis (*Threskiornis molucca*), and a number of duck species. In particular, Australian Wood Duck (*Chenonetta jubata)* were observed in their thousands (pers. comm. Paul Haw [community member], 9 December 2009). Tree hollows situated within the wetland provide important breeding habitat for a variety of species (including Australian Wood Duck, Grey Teal (*Anas gracilis*) and Chestnut Teal (*Anas castanea*). More than eighty bird species have been recorded at Lake Yando with records indicating that 18 are of conservation significance at an international, national and/or state level (Table 1 and Appendix E).

Lake Yando also provides important habitat for a variety of reptiles, amphibians and fish. Database records indicate that the wetland once supported the threatened Murray Hardyhead (*Craterocephalus fluviatilis*) and Freshwater Catfish (*Tandanus tandanus*). In addition, records indicate that a number of listed reptiles have been observed at Lake Yando (Table 1 and Appendix E). The recent watering event was extremely productive for amphibians with a range of species heard calling (pers. comm. Paul Haw [community member], 9 December 2009).

During the dry phase Lake Yando supports a range of other species including woodland birds, possums and wallabies (pers. comm. Rob O'Brien [NVIRP], 16 April 2010).

Table 1: Significant fauna species recorded in Lake Yando

Scientific Name	Common Name	Treaty	EPBC status	FFG status	DSE status
Birds					
Acrocephalus stentoreus	Clamorous Reed Warbler	B			
Anas rhynchotis	Australasian Shoveler				VU
Ardea intermedia	Intermediate Egret			L	CR
Ardea modesta	Eastern Great Egret	C/J		L	VU
Aythya australis	Hardhead				VU
Biziura lobata	Musk Duck				VU
Chlidonias hybridus	Whiskered Tern				NT
Climacteris picumnus victoriae	Brown Treecreeper (south-eastern ssp.)				NT

Scientific Name	Common Name	Treaty	EPBC status	FFG status	DSE status
Egretta garzetta	Little Egret			L	EN
Haliaeetus leucogaster	White-bellied Sea-Eagle	C		L	VU
Lophocroa leadbeateri	Major Mitchell's Cockatoo			L	VU
Merops ornatus	Rainbow Bee-eater	J			
Oxyura australis	Blue-billed Duck			L	EN
Platalea regia	Royal Spoonbill				VU
Plegadis falcinellus	Glossy Ibis	B/C			NT
Pomatostomus temporalis	Grey-crowned Babbler			L	EN
Stictonetta naevosa	Freckled Duck			L	EN
Tringa nebularia	Common Greenshank	B/C/J/R			
Fish					
Craterocephalus fluviatilis	Murray Hardyhead		VU	L	CR
Tandanus tandanus	Freshwater Catfish			L	EN
Reptiles					
Delma impar	Striped Legless Lizard		VU	L	EN
Morelia spilota metcalfei	Carpet Python			L	EN
Pogona barbata	Bearded Dragon				DD
Varanus varius	Lace Monitor				VU

Conservation Status:

- J/C/R/B: JAMBA/CAMBA/ROKAMBA/BONN International agreements listed in Section 2.3.1
- EPBC Listed: VU – Vulnerable
- FFG listing: L – Listed as threatened
- DSE listing: CR – Critically Endangered, EN – Endangered, VU – Vulnerable, NT – Near Threatened (DSE 2007a)

3.2. Flora

According to DSE's pre-1750 Ecological Vegetation Class (EVC) mapping, prior to European settlement Lake Yando was dominated by Lignum Swamp vegetation (EVC 104) surrounded by Lignum Swampy Woodland (EVC 823) vegetation (DSE 2009e). DSE's 2005 EVC mapping suggests that the above EVCs are still present; however Lignum Swampy Woodland has diminished in extent (DSE 2009f).

DSE's 2005 EVC mapping has been 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).

However, assessments undertaken by the Murray-Darling Freshwater Research Centre (Campbell *et al.* 2009) on 22 October 2009 identified that the wetland is currently characterised by Red Gum Swamp (EVC 292) with a patch of Riverine Chenopod Woodland (EVC 103) vegetation to the southwest continuing as a narrow fringe along the west and north-west boundary (Table 2 and Appendix F). The results of the assessment show a marked difference to the mapped 2005 EVCs and are based on recently mapped, up-to-date and field verified information. Therefore, the EVCs reported by MDFRC are included within the EWP as opposed to the mapped 2005 EVCs.

Table 2: Current EVCs within Lake Yando and their bioregional conservation status (Campbell *et al*. 2009)

EVC No.	EVC	Bioregional Conservation Status*
292	Red Gum Swamp	Vulnerable
103	Riverine Chenopod Woodland	Vulnerable

*Victorian Riverina bioregion

Six Victorian rare or threatened flora species (VROTS) have been recorded at Lake Yando (Table 3 and Appendix E). Spiny Lignum (*Muehlenbeckia horrida* subsp. *horrida*) and Winged Water-starwort are considered rare within Victoria (DSE 2005a). Winged Water-starwort is a mostly amphibious herb, spreading or submerged, with weak, thin stems. It is commonly annual but can be perennial. It is scattered and uncommon, found mainly in inland parts of Victoria, in damp and swampy habitats (Walsh and Entwistle 1999). Bladder Saltbush (*Atriplex vesicaria*) and Peppercress (*Lepidium pseudohyssopifolium*) have a 'poorly known' status. VEAC (2008) identify Bladder Saltbush, Peppercress and Spiny Lignum as rare and threatened flood dependent flora species. Two additional species recorded at the wetland are protected by the *FFG Act* as they are part of the Asteraceae family (DSE 2009d).

Table 3: Significant flora species recorded at Lake Yando

Common Name	Scientific name	EPBC status	FFG status	DSE status
Bladder saltbush[4]	*Atriplex vesicaria*[5]			k
Jersey Cudweed	*Psuedognaphalium luteo-album*		P	
New Holland Daisy	*Vittadinia sp.*		P	
Peppercress	*Lepidium pseudohyssopifolium*			k
Spiny Lignum[6]	*Muehlenbeckia horrida* subsp. *horrida*			r
Winged Water-starwort	*Callitriche umbonata*			r

Conservation Status:

- FFG listing: L – Listed as threatened, P – Protected (DSE 2009d)
- DSE 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 (DSE 2005a).

3.3. Representativeness and distinctiveness

Lake Yando is currently classified as a deep freshwater marsh supporting open water, reed and Red Gum vegetation (DSE 2009g). Deep freshwater marshes are often drained to facilitate agricultural activities, including grazing or cropping, and have 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). Table 4 illustrates the area and proportion of deep freshwater marshes across various defined landscapes. Lake Yando is classified as a deep freshwater marsh, the most depleted wetland category within Victoria.

Table 4: Current area of deep freshwater marsh wetlands across the landscape

	North Central region	GMID	Victorian Riverina
Deep freshwater marshes (ha)	4,880	7297	6364
Lake Yando	2%	1%	1%

Lake Yando is distinctive as it continues to display Red Gum Swamp (EVE 292) vegetation within a largely agricultural landscape and exhibits gilgai micro-topography with numerous small depressions and rises (Price Merrett Consulting 2006). Few other wetlands within the region continue to support River Red Gum vegetation having been cleared for a variety of purposes (e.g. Lake Leaghur, Little Lake Boort).

[4] pers. comm. Paul Haw [community member], 9 December 2009.

[5] Subspecies to be confirmed.

4. Hydrology

Wetland hydrology is the most important determinant in the establishment and maintenance of wetland types and processes. It affects the chemical and physical attributes of a wetland, which in turn affects the type of values the wetland supports (DSE 2005b). A wetland's hydrology is determined by surface and groundwater inflows and outflows, in addition to precipitation and evapotranspiration (Mitsch and Gosselink 2000, cited in DSE 2005b). Duration, frequency and seasonality (timing of inundation) are the main components of the hydrologic regime for wetlands.

4.1. Natural water regime

Lake Yando is located within the Wandella Creek sub-catchment of Loddon River Basin. The Loddon River floodplain and its wetlands would have experienced highly variable rainfall and flooding conditions (Appendix B), a significant driving force behind the natural water regime at Lake Yando.

Functioning as a depression within a complex interconnecting creek system, it would have been filled and flushed in winter/spring when Loddon River floodwater fanned out across the floodplain (Appendix B). It was filled from an unnamed distributary of Venables Creek that enters the wetland to the south. In years of larger floods, Lake Yando would have also received water from Kinypanial Creek via Lake Boort and Lake Lyndger (Lugg *et al.* 1993).

Naturally, floodwaters overflowed out of the wetland in a northerly direction at different locations and widths depending on flood levels. Lake Yando only held water for several months following a flood event and would have dried out frequently (Appendix B).

4.2. History of water management

Following development of the irrigation system around the 1920s/1930s, Lake Yando was flooded for prolonged periods. Construction of levees across the floodplain channelled water through the waterways preventing sheet flooding of the area. In addition, the influence of 'Black Fellows Cutting' at Fernihurst was significant by pushing additional floodwater through the Boort wetlands (Appendix B). Between the 1950s and 1970s, for example, the wetland was kept mostly permanent (O'Brien and Joyce 2002). This more permanent regime contributed to River Red Gum tree death in parts of the wetland and expansion of Cumbungi (Appendix B).

Although not reflected in the monitoring record of recent years (between 1997/98 and 2009/10), anecdotal evidence suggests that in the 1960s/1970s Lake Yando received significant volumes[6] of channel outfall water, channel drainage and drainage water from the local catchment to the south (Appendix B). The irrigation supply system delivered water to the east of the wetland which, in drier times, has contributed to maintaining the health of River Red Gums and emergent aquatic vegetation in this area. Local catchment drainage was delivered by the breakaway that enters the wetland to the south. Under the Boort West of Loddon Land and Water Management Plan, a monitoring station was installed in an attempt to measure the volume of water received from irrigation drainage. In 1996, as part of this plan, the sill of the overflow creek was lowered to slightly reduce its depth and improve the water regime and condition of the wetland (Appendix B). Surface water data (depth and salinity) collected by DPI between 1990 and 2007 is poor with several gaps in the monitoring record. However, it shows fluctuating surface water levels prior to 1997. Lake Yando was almost dry in November 1997 and was completely dry by December 1997.

Irrigation outfalls have declined dramatically over the past 80 years, reflecting fluctuating climatic conditions, improvements in irrigation efficiencies and agricultural practices over time (O'Brien and Joyce 2002). In particular, outfall volumes have reduced significantly in the past 10 to 15 years (since 1995), with zero outfalls recorded since 2006/07 (Figure 4). An improvement in G-MW water delivery since 1999 contributed to an extended dry period at Lake Yando since 1996/97 (Table 5 and Figure 4). In addition, irrigation tail water runoff into the wetland has completely ceased as irrigation efficiency has improved (Appendix B).

[6] Relative to the storage capacity of the wetland

An environmental flow (totalling 757 ML), sourced from the Murray Flora and Fauna Bulk Entitlement, was delivered in November 2009 for approximately 20 days (Figure 4). An inspection undertaken on 19 March 2010 reported that water was persisting in deeper sections of Lake Yando (Plate 3 and Plate 4).

Table 5: Lake Yando wetting/drying calendar (NCCMA 2008)

93/94	94/95	95/96	96/97	97/98	98/99	99/00	00/01	01/02	02/03	03/04	04/05	05/06	06/07	07/08	08/09	09/10
w	w	w	w	D	D	D	D	D	D	D	D	D	D	D	D	w/D

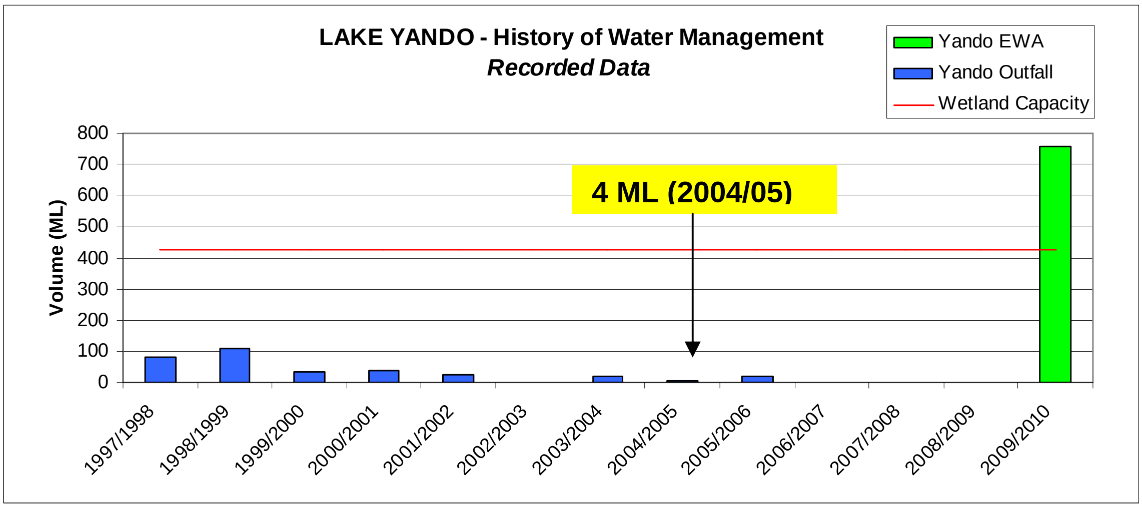


Figure 4: Recorded volumes received by Lake Yando from outfalls and environmental allocations *Note: outfalls recorded from 1997/1998 onwards*

Plate 3: Water persisting in deeper sections of Lake Yando (Source: NCCMA 2010)

Plate 4: Water persisting in deeper sections of Lake Yando (Source: NCCMA 2010)

4.2.1. Recorded outfalls and NVIRP

Anecdotal evidence suggests that Lake Yando received significant volumes of channel outfall water in the 1960s/1970s, having declined significantly since (Appendix B). However, this is not illustrated in the monitoring record of more recent years displayed in Figure 4 as outfall data for Lake Yando has only been recorded by G-MW since 1997/98. Historically, larger outfall volumes provided a wetter water regime (O'Brien and Joyce 2002).

The baseline water year, 2004-2005, has been selected to quantify the savings as part of water savings projects (DSE 2009h). The comparison of estimated water savings with a baseline year is necessary to convert the savings to water entitlements and ensure that there are no impacts on service delivery or reliability for existing entitlement holders (DSE 2008b). This baseline year will also be used to guide the quantification of mitigation water required for wetlands (discussed in Section 5), taking into account the average annual patterns of availability.

The outfall water recorded at the regulating structure that delivers water to Lake Yando was a total of 4 ML in 2004-2005.

4.3. Surface water/groundwater interactions

Lake Yando is situated on the Loddon River floodplain on the western edge of lower floodplain alluvial sediments. It is approximately 3.8 km west of the Loddon River. Shepparton Formation sediments outcrop on the western and northeast sides of Lake Yando and Parilla Sand sediments outcrop 4 km to the northwest, in proximity to the Leaghur Fault. The alluvial/Shepparton Formation sediments comprise sandy clay and clay, and are approximately 40 m thick at the wetland, overlying Parilla Sand and Renmark Group sediments.

Groundwater movement beneath the floodplain west of the Loddon River is from the south and southeast toward the north and northwest.

Groundwater monitoring within the vicinity of Lake Yando has been conducted by DSE and DPI (Future Farming Systems Research) since 1990. DSE collect groundwater data from regional bores in the State Observation Bore Network whilst data is collected from other bores within the vicinity by DPI. Regular monitoring of surface water and electrical conductivity (EC) commenced in 1990 and is also undertaken by DPI.

Regional groundwater levels have been declining since the late 1990s, which corresponds with an extended period of below average rainfall. The drier period and lower irrigation allocations have meant less recharge to groundwater from rainfall, from flooding or from surface waterbodies, and from irrigation accessions. Figure 5 illustrates groundwater behaviour from within the vicinity of Lake Yando. This figure shows the regional decline in groundwater levels.

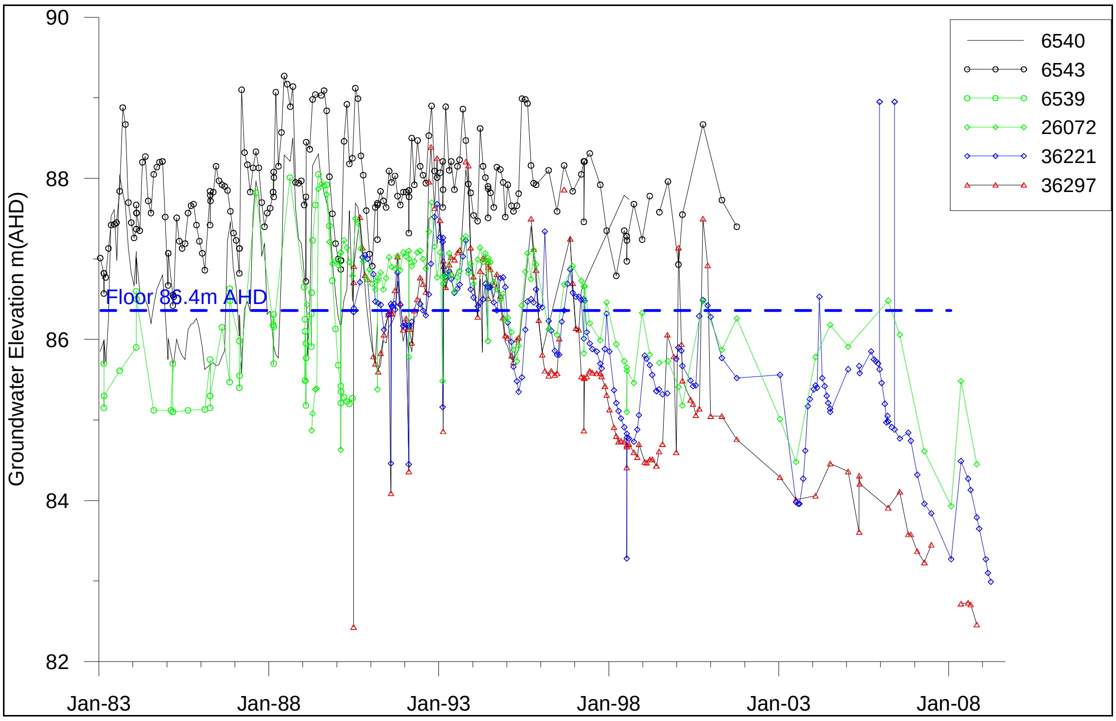


Figure 5: Groundwater levels from bores to the west, east and southeast of Lake Yando (Source: Bartley Consulting 2010)

Groundwater levels within close proximity to Lake Yando have fluctuated over time (Figure 6). The figure shows fluctuations typical of a relatively shallow watertable. The levels peaked in January 1993, declined to early 1995, and then peaked again in late 1995 and late 1996. The decline in groundwater levels observed since late 1996 are at a similar rate to the regional decline.

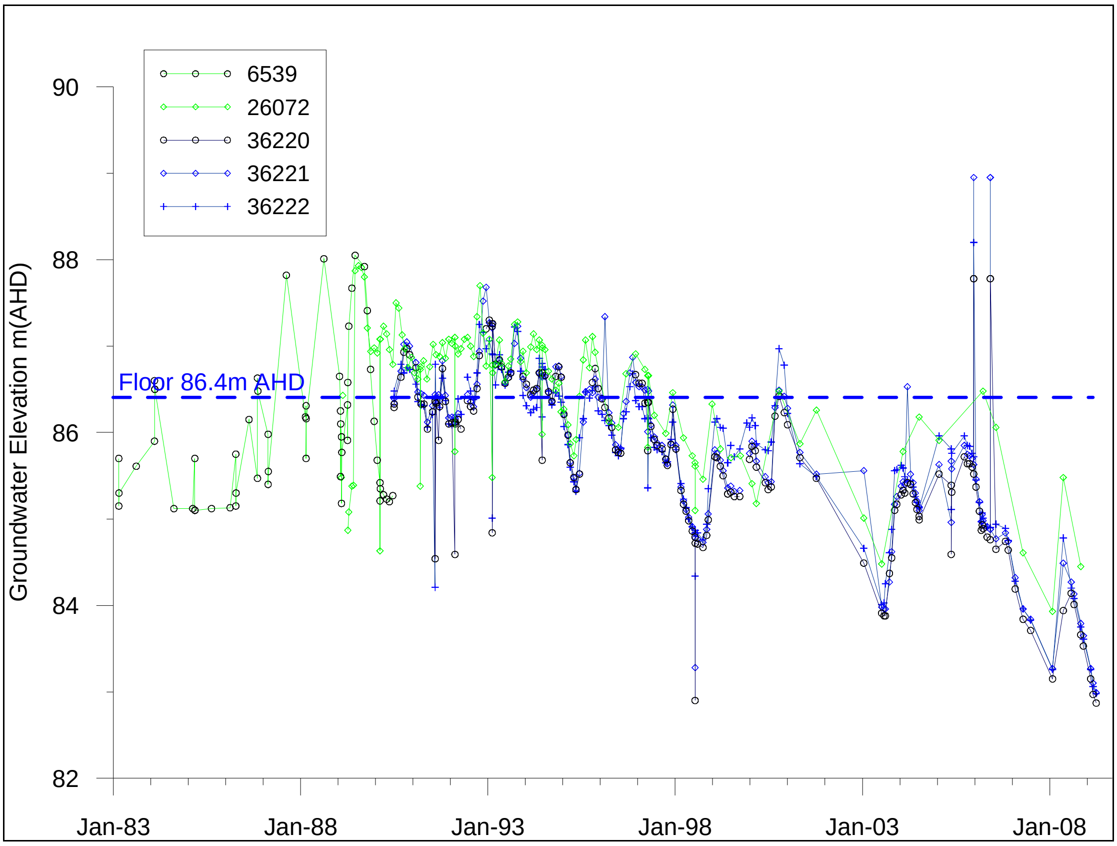


Figure 6: Groundwater levels from bores on the northwest edge of Lake Yando ((36220, 362221, 36222) and 500 m to the southwest (6539, 26072)
(Source: Bartley Consulting 2010)

The monitoring record illustrates that surface water levels at Lake Yando were similar to the groundwater level in adjacent monitoring bores. In these periods Lake Yando could have been a local source of groundwater recharge. However, once the surface water level declined, groundwater could have discharged to the wetland. Locals have advised that saline areas were appearing within Lake Yando, particularly on the south-eastern side, during the wet period 1950s to 1990s.

The current groundwater level at bore 36221 is at least 3 m below the lake floor level and groundwater discharge to the lake floor is unlikely to occur. Anecdotal evidence suggests current groundwater levels could be as deep as 5 m below the bed in some places (Appendix B).

Data from bores within the vicinity of Lake Yando show fluctuating EC levels (Table 6). Overall, groundwater EC is considered high (>15,000 uS/cm) throughout the area, with slightly lower levels in bores to the east of Lake Yando (6558, 36223, 36224 and 36225) close to the Loddon River. Analysis of the monitoring record shows extremely high EC levels (maximum >30,000 uS/cm) in bores close to Lake Yando (36220, 36221, 36222 and 6539, 26072).

Table 6: Analysis results of monitoring bores within the vicinity of Lake Yando (Source: Bartley Consulting 2010)

Bore	Location	Drilled depth	Screen top (m)	Screen bottom (m)	Electrical Conductivity (uS/cm)			
					Min	Max	Mean	Readings
6539	500m west of southern edge	3.05			2310	52833	28775	14
26072		11.78	9.56	11.56	31000	42612	38866	12
36220	Northwest edge	10.00	7.74	9.74	2131	30000	12469	13
36221		10.00	7.97	9.97	20980	34036	29177	13
36222		10.09	8.09	10.09	26200	33528	30684	13

Bore	Location	Drilled depth	Screen top (m)	Screen bottom (m)	Electrical Conductivity (uS/cm)			
					Min	Max	Mean	Readings
6538	3.2km northwest (adj. channel)	3.05						
6594		9.00			2700	25149	13545	10
26066		11.62	9.42	11.42	18400	27200	20757	13
6536	1.3km northwest	3.05			8550	23333	12403	19
6535	3.4km northwest	3.05			1683	34333	17246	19
50983		112.50	84.00	90.00	1400	1400	1400	1
50984		76.00	66.00	72.00	20000	20000	20000	1
6540	2.1km east	3.05			1666	23333	17472	24
36296		5.50	3.47	5.47	17001	27600	22454	11
36297		7.00	4.98	6.98	4867	31500	22996	11
36298		7.78	5.50	7.50	6988	26000	17561	11
6558	3.8km east	11.00			1675	32130	15954	11
36223		9.00	6.51	8.51	13800	26703	17095	11
36224		8.49	6.49	8.49	5973	29000	22351	11
36225		7.26	5.08	7.08	934	35000	12062	11
6541	4.4km southwest	3.05			13000	25960	18360	26
6542	2.5km south	3.05			12900	43333	25031	24
6543	2.5km southeast	3.05			3333	21500	16363	25
50971	2.6km east	162.76	42.67	51.81	22143	26000	23509	5
50972	3km southeast	88.39	0.00	88.39	13000	25929	15726	5
50973	3km east	78.33	73.15	78.33	23095	23095	23095	1

Lake Yando has been dry, and received negligible channel outfalls, since 1997. Prior to this, however, surface water EC levels have fluctuated over time from 680 uS/cm to 6800 uS/cm, with a median of 2360 uS/cm (53 readings). Although the monitoring record is incomplete with many gaps, the lower EC appears to correspond with periods when the water level is high, and higher EC with low water level, indicating concentration of salt by evaporation.

Based on the analysis of current groundwater levels at Lake Yando (Bartley Consulting 2010):

- The greatest risk of watertable rise to within the capillary fringe in surrounding areas is when there is high water level in the lake combined with high regional groundwater levels.
- Intermittently inundating Lake Yando is likely to result in a local temporary impact on watertable level. However, as groundwater levels are currently >3 m deep there is no significant risk of adverse impact on the wetland or neighbouring land through watertable rise.
- Putting water into Lake Yando when groundwater levels are low increases the opportunity for salts to move down the profile and into the groundwater.
- The monitoring record shows a relatively rapid decline in groundwater levels adjacent to the wetland when the surface water level declines. However, if Lake Yando was maintained as a permanent wetland, it would be a continual source of recharge to the groundwater. Consequently, the watertable mound would grow, with an increased risk of discharge through evapotranspiration and to low lying areas on neighbouring land.

Source: Bartley Consulting 2010

4.4. Surface water balance

A daily surface water balance has been modelled in order to identify the hydrological attributes of Lake Yando. The model used is a simplified version of the Savings at Wetlands from Evapotranspiration daily Time-Series (SWET) model (Gippel 2005a, Gippel 2005b, Gippel 2005c).

This model has been approved by the Murray Darling Basin Authority for estimating the wetland surface water balance. Modelling the daily water balance enables managers to quantify the volumes required in providing the desired water regime. It also allows for consideration of variability in climatic conditions and wetland phase.

A surface water balance and associated calculations to define the hydrological characteristics of Lake Yando was undertaken as part of the development of the EWP. Components are discussed in brief below. Actual figures are provided in Section 5.3 and Appendix G. This information is utilised for the estimation of volumes required for the desired water regime (Section 5.3).

The main components of the model are outlined below:

- **Time Series:** the daily time step is set up to run from May 1891 to end of 2009.
- **Wetland capacity:** volume required to fill the wetland to the targeted supply level, i.e. Lake Yando filled to FSL (87.59 m AHD) has a storage capacity of 478 ML (Price Merrett Consulting 2006).
- **Infiltration:** volume required to fill the underlying soil profile. Calculation of this volume has been adapted from measurements undertaken by G-MW (G-MW 2008a) The following assumptions were included in the application of the SWET model for Lake Yando (Gippel 2005a, Gippel 2005b, Gippel 2005c):
    - Infiltration (ML) = Soil cracking (%) x area of wetland (ha) x depth (mm))/100
    - Soil cracking – 25% of surface area
    - Average depth of 300mm
    - Ongoing losses via infiltration are considered negligible due to the low permeability of the underlying soil (G-MW 2008b)
- **Rainfall/runoff:** this includes rainfall directly falling onto the wetland and surface run-off. Surface water inflows/run-off: an average volumetric figure of 0.2 ML/ha/year (DPI and HydroEnvironmental 2007). A small local catchment area of 50 ha directly sheds rainfall runoff into the creekline, then into the Lake Yando (pers. comm. Rod Stringer [landholder] and Lawrence Cameron [G-MW] 25 March 2010). The ability for the catchment to shed water depends upon climatic conditions, watertable height, whether surrounding land is irrigated or dryland agriculture and the amount and timing of the rain etc. In this heavy clay floodplain area it would take very high rainfall event to produce enough runoff that would make it into the wetland (i.e. 75 -100 mm)[7].
- **Climate data:** SILO DataDrill including wind data (Bureau of Meteorology)
- **Evaporation data:** a modelled approach (combination of the Penman-Monteith method with a deBruin adjustment; recommended by the CSIRO) to assessing evaporation at the wetland has been incorporated into the water balance (McJannet *et al*. 2009).

Please note:

- *Groundwater is not included in the model (Gippel 2010). While groundwater may contribute in some circumstances it is not readily quantifiable or not easily factored into the model.*
- *The modelling does not consider water diversion/extraction from Lake Yando as part of the overall surface water balance.*

[7] The recent high rainfall events have not resulted in any significant flows, from catchment areas that have entered the districts wetlands (pers. comm. Rod Stringer [landholder] and Lawrence Cameron [G-MW] 25 March 2010).

The modelling produces a range of volumes required to operate the wetland in accordance with the optimal regime specified in Section 5.3. The modelling results for Lake Yando are presented in Section 5.3 and Appendix G.

4.5. Operational uses

Lake Yando is used as an operational outfall, although the onset of drought initiatives and efficiency programs has considerably reduced outfall volumes with zero outfalls recorded since 2006/07. The storage capacity of Lake Yando is determined by an overflow sill situated on the northeast margin sitting at 87.59 m AHD (Price Merrett Consulting 2006).

Currently, an adjoining landholder has an existing diversion licence for Lake Yando. It was issued around the 1950s (Appendix B) and permits the opportunistic extraction of 120 ML from the wetland. However, it is understood that this licence has not been used in some time due to the prolonged dry conditions experienced at Lake Yando (pers. comm. Lawrence Cameron [G-MW] 3 March 2010).

5. Management objectives

Previous management recommendations for Lake Yando relate to protecting and enhancing the values supported by the wetland, in particular targeting the River Red Gum and Black Box vegetation.

Table 7 provides an outline of information and management recommendations from the Boort District Wetlands Vegetation Assessment (Ecos Environmental Consulting 2007).

Table 7: Previous management recommendations

Source	Objectives	Duration	Timing	Frequency
Ecos Environmental Consulting (2007)	• Enhance current environmental values (River Red Gum vegetation and associated habitat) o On year two or three flood to the upper part of the River Red Gum zone o After three to five years flood to the upper part of the black box zone o Manipulate surface water levels with sill levels to enable water to drain from the zones over a period of up to four months • Consider a small flood to inundate depressions every one to two years • After a flood allow water levels to recede through the 'rapid draw-down zones' within a year or less	Four months	Late winter/ spring	One in six to seven years

5.1. Water management goal

The water management goal for Lake Yando has been derived from a variety of sources including previous management goals, local expertise and knowledge, water availability and feasibility of delivery, and has been appraised by agency stakeholders and technical experts (wetland workshop, Appendix A, Table A2). It takes into consideration the values the wetland supports, the current wetland condition and potential risks that need to be managed.

Lake Yando water management goal:
To provide a water regime typical of a deep freshwater marsh[8] that supports the maintenance and recruitment of River Red Gums and promotes the growth of a diverse range of aquatic and amphibious plant species offering a variety of habitats to waterbirds, reptiles and amphibians.

5.2. Ecological objectives and hydrological requirements

Ecological objectives and hydrological requirements have been identified in determining a desired water regime to support high environmental values in Lake Yando (Table 8). The process for identifying ecological and hydrological objectives closely follows that recommended in FLOWs: a method for determining environmental flow requirements in Victoria (DNRE 2002). The ecological objectives outline the outcomes desired from delivery of the desired water regime.

Water dependent environmental values including habitat, species/communities and processes were identified from local anecdotal information, relevant reports, condition assessments, and records (such as the FIS and Atlas of Victorian Wildlife (AVW) databases).

[8] Deep freshwater marshes are generally less than 2 m deep and are inundated for longer than eight months of the year (DCFL 1989)

Ecological objectives were identified based on the environmental values in terms of the physical conditions (habitat objectives), species and/or biota (biodiversity objectives), and biological processes (process objectives) needed in order to achieve the water management goal.

Habitat objectives identify habitat components considered critical in achieving the water management goal. While it is recognised that each habitat component will attract an array of fauna species, examples of previously recorded listed species whose habitat requirements closely align with a specific component have been provided as potential indicator species. Those species and communities of international, national and state conservation significance were given highest priority as were those that are indicative of integrated ecosystem functioning.

The objectives were expressed as one of four types of target, which are related to the present condition/functionality of the value:

- Reinstate – no longer considered to occur
- Restore/Rehabilitate – severely impacted and only occur to a reduced extent
- Maintain – not severely impacted but are desirable as part of the ecosystem
- Reduce – have increased undesirably at the expense of other values.

Hydrological requirements describe the water regimes required for achieving ecological outcomes (ecological objectives) (DNRE 2002). All values identified have components of their life-cycle or process that are dependent on particular water regimes for success e.g. colonially breeding waterbirds require certain timing, duration and frequency of flooding to successfully breed and maintain their population. Requirements for the three components of a water regime[9] were identified and described for all of the ecological values.

Source: Campbell, Cooling & Hogan 2005.

The ecological objectives and hydrological requirements for Lake Yando were developed in conjunction with agency stakeholders and technical experts at the Wetland Workshop held on 25 February 2010.

Table 8: Lake Yando proposed ecological objectives and water regime

Ecological Objective	Justification	Hydrological Requirement
1. Habitat Objectives		
1.1 Maintain the health and restore the distribution of River Red Gum (EVC 292) • Maintain health of existing trees • Provide opportunities for recruitment in the western half of the wetland	River Red Gum trees provide hollows, fallen branches and shading for habitat, and provide a source of seed for recruitment.	Inundate to FSL (87.59 m AHD[10]) one in three years and allow natural draw-down over approximately five months.
1.2 Maintain open water and associated mudflat habitat in sections of the wetland	Provides habitat for waterbirds e.g. Australasian Shoveler, Intermediate Egret, Eastern Great Egret, Hardhead, Musk Duck, Little Egret, Glossy Ibis	Inundate to a minimum depth 50 cm one in three years
1.3 Maintain the health and restore the distribution of the fringing Riverine Chenopod Woodland (EVC 103) • Maintain health of existing trees • Provide opportunities for recruitment	Black Box trees provide hollows, fallen branches and shading for habitat (e.g. White-bellied Sea-Eagle and Grey-crowned Babbler), and provide a source of seed for recruitment.	Inundate to 87.8 m AHD one in six years for two to three months.
1.4 Maintain health and restore the distribution of Tangled Lignum vegetation across a greater range of elevations at	Tangled Lignum provides habitat for waterbirds e.g. Whiskered Tern, Freckled Duck	Inundate to 87.8 m AHD one in six years for two to three months.

[9] Timing, frequency and duration

[10] Refer to Appendix K: for comparison of bathymetric information and vegetation mapping.

Ecological Objective	Justification	Hydrological Requirement
Lake Yando		
1.5 Restore diverse aquatic and amphibious plant species communities in the Gilgai micro-topography	Provide a range of micro-habitats to support a diverse array of plants, birds, frogs and invertebrates.	Inundate one in three years.
2. Species/Community Objectives		
2.1 Restore habitat for the rare Winged Water-starwort	Provide the habitat to support and expand the population of this rare plant species	Little appears to be known about water requirements
2.2 Restore feeding and breeding opportunities for waterbirds, frogs and invertebrates	Linked to habitat objectives. Providing a variety of habitat types and high productivity of micro and macro-invertebrates and plant species through a wetting and drying cycle should enable breeding opportunities.	Fill to FSL (87.59 m AHD) in spring and inundate for seven to ten months.
2.3 Ensure a viable seed and egg bank is maintained	Seed and egg banks provide a source of survival for invertebrates and macrophytes in temporary wetlands during dry periods. These habitat and food sources in turn support higher order consumers such as waterbirds, frogs and fish.	Duration variable and seasonally dependent but maintain inundation for a minimum of three months one in three years.

5.3. Desired water regime

A desired water regime has been defined for Lake Yando and is presented below. This regime is based on the ecological objectives and hydrological requirements outlined in Section 5.2. The proposed regime aims to reinstate an intermittent[11] water regime at a wetland that has largely been dry since 1997 except for the recent environmental watering event.

Figure 7 below illustrates the various components of the wetland (e.g. River Red Gum, open water and associated mudflats, Black Box, Tangled Lignum, aquatic vegetation) that are being targeted by the water regime.

Timing: Winter/spring

Frequency of wetting: Minimum: one in five years

Optimum: one in three years

Maximum: one in two years

Duration: Variable (habitat dependant). Approximately five months in Red Gum Swamp (EVC 292) vegetation allowing for natural draw-down, two – three months in areas of Black Box and Tangled Lignum vegetation (EVC 103: Riverine Chenopod Woodland). Top-ups may be required to maintain duration depending on the waterbird breeding response.

Extent and depth: Dependant on objective targeted

- Inundate the base of wetland to a minimum depth of 50 cm for longer than three months for River Red Gums and establishment of aquatic/amphibious plant species.
- Inundate entire wetland into Black Box and Tangled Lignum areas for two – three months; depth not important
- Allow draw-down via evaporation (duration of approximately five months unless top-ups are required in response to waterbird breeding) facilitating the exposure of mudflat habitat with receding water levels

Variability: High (target levels and corresponding duration)

[11] Alternatively wet and dry but less frequently and regularly than seasonal wetlands. Surface water persists for months to years (extended from Paijmans *et al. 1985* in Boulton and Brock 1999)

Wetland water regime:
Fill Lake Yando to FSL (87.59 m AHD)[12] to inundate River Red Gum Swamp community (EVC 292) one in three years for approximately five months allowing for natural draw-down.

Top-ups may be required to extend the duration depending on the waterbird response. Push water into Riverine Chenopod Woodland (EVC 103) one in six years (87.8 m AHD); ensure these communities are not inundated for more than three months. Allow majority of wetland to dry between watering events. Gilgai depressions may stay damp or retain water between floods.

Please refer to the figures in Appendix G for the modelled desired water regime.

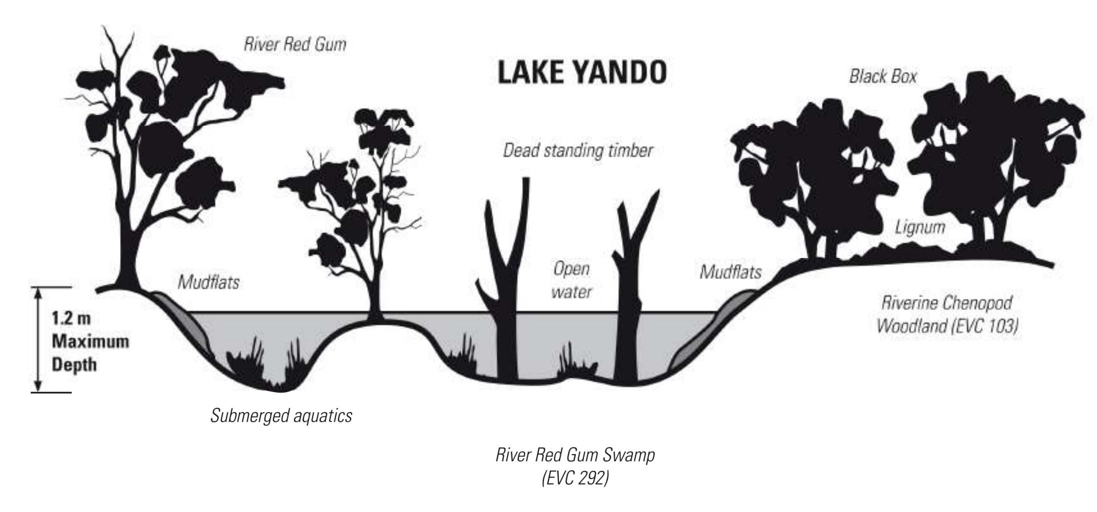


Figure 7: Schematic of wetland areas to be targeted (not to scale)

The volumes of water required to provide the desired water regime for Lake Yando are presented in Table 9. These volumes reflect the results from the SWET modelling (model described in Section 4.4 and results presented in Appendix G). The calculations below are based on filling to Lake Yando to FSL (87.59 m AHD) one in three years, and one in six years to 87.8 m AHD to inundate the Riverine Chenopod Woodland vegetation.

Table 9: Volumes required in providing the desired water regime for Lake Yando (SWET modelling output)

Result	
Mean long-term (LT) annual controlled inflow requirement	284 ML/year
95th percentile of mean LT annual controlled inflow requirement	904 ML/year
Average LT controlled inflow requirement for filling periods	836 ML
Record length	118
No. of periods	40
Years with no inflow	78 in 118 years
No. of draw downs over record	39
No. of draw downs not fully drawn down	0
% of draw downs not fully drawn down	0%
95th percentile duration of full period (months)	4.5
50th percentile duration of full period (months)	3.2

A brief description of each the main results provided is below:

- **Mean long-term annual controlled inflow requirement**: the total amount of water required to be delivered into the wetland annually in a controlled fashion to achieve the specified level and the desired regime (excluding natural inflows from rainfall and local catchment runoff). This is the average over the modelled period (three years), which may include years with zero water required (i.e. water is only required in year one). A mean long term annual volume of 248 ML is required to fill Lake Yando to 87.59 m AHD one in three years and surcharge water levels to 87.8 m AHD one in six years in order to inundate the Riverine Chenopod Woodland (EVC 103) vegetation.

[12] High amount of variability is important and the target level should be managed adaptively

- **95th percentile of mean long-term annual controlled inflow requirement**: an estimate of the maximum volume ever likely to be required over any 12 month period (904 ML).
- **Average long-term controlled inflow requirement for filling period:** the total amount of water required to be delivered to the wetland in a controlled fashion to achieve the desired water level regime for the recommended cycle (i.e. three years). This excludes natural inflows from rainfall and local catchment runoff. Therefore, the total volume required to fill Lake Yando to 87.59 m AHD one in three years and surcharge water levels to 87.8 m AHD one in six years in order to inundate the Riverine Chenopod Woodland (EVC 103) vegetation would be approximately 836 ML.

Refer to Appendix G for greater detail.

Please note: due to the variability of inflows to the wetland, particularly in response to current climate conditions, determination of inflows from local rainfall and runoff in any one year will need to be undertaken by the environmental water manager when watering is planned. Surface water inflows to Lake Yando and rainfall will vary considerably from year to year, depending on seasonal conditions.

5.4. Mitigation water

The volume of water that is required to offset the impact of NVIRP on wetlands that have become reliant on this water to support high environmental values is termed ‘mitigation’ water. The potential impact of NVIRP considered in the Lake Yando EWP is related mainly to a reduction in outfalls. Other potential impacts to the wetland will be managed in accordance with the Water Change Management Framework (NVIRP 2010) and Site Environmental Management Plans.

Guiding principles for mitigation water based on government policy have been defined by the Water Change Management Framework and are:

1. Water savings are the total (gross) volumes saved less the volume of water required to ensure no net impacts due to the project on high environmental values
2. Using the same baseline year (2004–05) as that used to quantify savings, taking into account the long-term average annual patterns of availability.
3. The mitigation water will be deployed according to the EWP.
4. Sources of mitigation water will be selected to ensure water can be delivered in accordance with the delivery requirements as specified in the environmental watering plans. Water quality will need to be considered for all sources of water to ensure it is appropriate.

In the majority of cases, actual outfall volumes will be less than what is required to support all water dependent environmental values of a particular wetland. Therefore, the outfall water only forms part of the overall volume required to provide the water regime of the wetland. The water regime supports processes and systems which in turn provide suitable conditions for defined ecological values (e.g. breeding of waterbirds).

A process for calculating mitigation water based on the best available information has been developed and involves the application of a series of steps that includes:

Step 1: Describe the desired water or flow regime

Step 2: Determine the baseline year incidental water contribution

Step 3: Assess dependency on baseline incidental water contributions

Step 4: Calculate the annualised baseline mitigation water volume

Step 5: Calculate the mitigation water commitment

Step 6: Calculate the LTCE mitigation water volume

5.4.1. Lake Yando mitigation water

Step 1: Describe the desired water or flow regime

The desired water regime for Lake Yando is filling it to FSL[13] one in three years, with higher levels (87.8 m AHD) to inundate the Riverine Chenopod Woodland one in six years. Further detail is provided in Section 5.3.

For this three year cycle, the total volume required is 836 ML. The 95% percentile mean annual volume required equates to 904 ML.

Step 2: Determine the baseline year incidental water contribution[13]

This step determines the baseline year incidental water for each hydrological connection assessed (e.g. outfalls, leakage and seepage) and the incidental water contribution both as it leaves the irrigation system and as it arrives at the wetland.

Leakage and seepage have not been accounted for within the following steps. Preliminary calculations to estimate the potential contributions to Lake Yando from leakage and seepage from the no. 5/2 channel were completed based on the localised impact assessment method outlined in the Water Change Management Framework (NVIRP 2010). As Lake Yando is greater than 200 m from the main supply channel, leakage and seepage from this channel are not considered to contribute to the surface water balance of the wetland (Appendix H). However, if future NVIRP actions are likely to impact the potential for leakage and seepage to Lake Yando (for example decommissioning any spur channels within 200 m of the wetland), an analysis will be triggered in accordance with the Water Change Management Framework.

Therefore, only one hydrological connection (outfalls) is included within the mitigation water assessment and the potential contributions from leakage and seepage are excluded.

The baseline year (2004-05) outfall volume recorded at the regulating structure was 4 ML, refer to Section 4.1. A channel approximately 700 m in length delivers water from the regulating structure to the wetland. An estimated 50 ML/km/year[14] are lost from an open channel as a result of evaporation and seepage (pers. comm. Chris Solum [NVIRP], 27 January 2010). Based on conservative assumptions relating to channel wetness when outfalls occur, and with an average fill time of approximately 76 days (based on 6 ML/day[15]), the loss from the open channel is estimated to be 10 ML. Therefore, **none of the outfall volume is estimated as having contributed to the wetland's water balance in 2004-05 and mitigation water is not required.**

The determination of the baseline year incidental water contribution is summarised in Table 10.

Table 10: Determination of the baseline year incidental water contribution

Hydrological connection or incidental water source (e.g. Outfall #)	Baseline year incidental water at origin (Gross) (ML)	Estimated losses between the origin (irrigation system) and wetland (for baseline year) (ML)	Baseline year incidental water contribution at the wetland (Net) (ML)
Outfall #ST025270	4	10	0

Step 3: Assess dependency on baseline incidental water contributions

The Water Change Management Framework (NVIRP 2010) specifies criteria to be applied in assessing whether mitigation water is required for a wetland or waterway with high environmental values. These criteria have been assessed for Lake Yando with the results presented in Table 11.

[13] Incidental water contributed in the baseline year for each hydrological connection i.e. outfall water, seepage and leakage of a supply channel within 200m of the wetland.
[14] These losses assume the channel is constantly inundated. Therefore losses may vary (either more or less) depending on the length of intervals between outfalls (pers. comm. Chris Solum [NVIRP] 30 March 2010).
[15] Prior to recent upgrade works the delivery rate was limited to an estimated 6 ML/day (Hillemacher and Ivezich 2008). This is the presumed capacity for the baseline year.

Table 11: Mitigation water dependency assessment

Criteria by which mitigation water may be assessed as not required	Link between incidental water (losses) and environmental values
1. Mitigation water may be assessed as not required where:	
1.1 There is no hydraulic connection (direct or indirect) between the irrigation system and the wetland or waterway	A channel (700 m in length) delivers outfall water to Lake Yando from the regulating structure.
1.2 The water does not reach the wetland or waterway with environmental values (e.g. the outfall is distant from the site and water is lost through seepage and evaporation before reaching the area with environmental values)	The delivery channel is approximately 700 m in length. There are no diversions or impediments restricting outfalls being delivered to Lake Yando. **However, it is estimated that none of this outfall water reached Lake Yando as a result of losses associated with an open delivery channel of 700 m in length.**
2. Mitigation water may be assessed as not required where the wetland or waterway receives water from the irrigation system:	
2.1 That is surplus to the water required to support the environmental values (e.g. changing from a permanently wet to an intermittently wet or ephemeral regime is beneficial or has no impact)	Losses did not reach the wetland therefore this criteria has not been assessed.
2.2 That occurs at a time that is detrimental to the environmental values	Losses did not reach the wetland therefore this criteria has not been assessed.
2.3 That is of poor quality (or results in water of poor quality entering a site e.g. seepage resulting in saline groundwater intrusions to wetlands) and the removal of which would lead to an improvement in the environmental values	Losses did not reach the wetland therefore this criteria has not been assessed.
3. Mitigation water may be assessed as not required where the environmental values:	
3.1 Do not directly benefit from the contribution from the irrigation system (e.g. River Red Gums around a lake may not directly benefit from an outfall and may be more dependent on rainfall or flooding)	In the baseline year, losses did not contribute to the surface water balance of the wetland, therefore not benefiting the environmental values supported by the wetland.
4. Mitigation water may be assessed as not required where the removal of the contribution from the irrigation system does not:	
4.1 Increase the risk of reducing the environmental values (e.g. outfalls form a very small proportion of the water required to support the environmental values and their removal will not increase the level of risk)	Removal of losses would not have demonstrable impacts on the high environmental values of Lake Yando. The 04/05 volume equates to <1% of the total volume required to deliver the desired water regime.
4.2 Diminish the benefits of deploying any environmental water allocations (over and above the contribution from the irrigation system).	Additional water would need to be secured for providing the desired water regime recommended for Lake Yando.

The assessment of the requirement for mitigation water for Lake Yando suggests that **mitigation water is not required to maintain the environmental values of the wetland.** Calculations indicate that losses in the baseline year (2004/05) did not contribute to the wetlands surface water balance and therefore did not directly benefit the environmental values displayed at Lake Yando.

Please note: due to the recommendation above Steps 4, 5 and 6 do not need to be calculated.

5.5. Other water sources

As noted above, mitigation water is not proposed for Lake Yando. NVIRP are only accountable for mitigating any potential impact from the project i.e. for provision of mitigation water as a proportion of the total outfall, seepage and leakage volumes received by the wetland if they are supporting significant environmental values. As such, it is important for the environmental water holder to secure additional sources of water to provide the desired water regime for Lake Yando. The most likely additional sources of water will be existing and future environmental entitlements.

Discussion of potential sources of environmental water to provide the desired water regime to support high environmental values at Lake Yando follows.

5.5.1. Murray flora and fauna bulk entitlement

In 1987, an annual allocation of 27,600 ML of high security water was committed to flora and fauna conservation in Victorian Murray wetlands. In 1999, this became a defined entitlement for the environment (DSE 2006). Each year, a prioritisation process is utilised to decide on the best use of the available water (based on River Murray allocations). An annual distribution program identifies wetlands that will receive a portion of the entitlement utilising a decision flowchart (DSE 2006).

5.5.2. 75 GL environmental entitlement

Water savings generated by NVIRP will provide up to 75 GL to be vested in the Minister for Environment and Climate Change as an Environmental Water Entitlement. This environmental water is in addition to Government's commitments to provide water for the Living Murray process and will be used to help improve the health of stressed wetlands and waterways in Northern Victoria and the River Murray (NVIRP 2010).

In addition, the Australian Government may co-invest in Stage 2 of NVIRP which will generate up to 100 GL of water savings, some of which will be allocated to the environment. This water will be available for use across the Murray Darling Basin.

5.5.3. Commonwealth environmental water

Under Water for the Future the Australian Government has committed $3.1 billion to purchase water in the Murray-Darling Basin over 10 years. The program will complement a range of other measures to address sustainable water management in the Basin. The Commonwealth Environmental Water Holder, in DEWHA, will manage the Commonwealth's environmental water.

The Water Act 2007 provides that “the Commonwealth Environmental Water Holder must perform its functions for the purpose of protecting or restoring environmental assets so as to give effect to relevant international agreements”. Wetlands of International Importance (Ramsar) are considered priority environmental assets for use of the commonwealth environmental water (DEWHA 2008). Whilst Lake Yando is not a wetland of international importance, it is a refuge for species listed under other international conventions. The *EPBC Act* listed Murray Hardyhead and Striped Legless Lizard (*Delma impar*) have also been recorded within the vicinity of Lake Yando. Based on the protected waterbirds observed at Lake Yando, a case for the receipt of Commonwealth environmental water could be made.

6. Potential risks or adverse impacts

An important component of the EWPs is the identification of potential risks, limiting factors and adverse impacts associated with the delivery of the desired watering regime of which, when recommended, mitigation water would form a portion. Awareness of the potential risks and impacts will influence future intervention and long-term condition monitoring undertaken at Lake Yando, will inform the adaptive management of the watering regime and the provision of mitigation water (Section 8). Based on the calculations presented in Section 5.4.1, no mitigation water is recommended to be delivered to Lake Yando.

Table 12 outlines the risks, limiting factors and potential impacts associated with the calculation and provision of mitigation water as a component of the desired watering regime that need to be considered by NVIRP in conjunction with the environmental water manager.

Appendix I outlines a range of additional risks and limiting factors identified which may arise as a direct result of, or in association with, implementing the desired water regime at Lake Yando. It is envisaged that these additional risks and limiting factors will be considered in the future management of the lake (i.e. management plan).

Mitigation measures have been recommended to minimise the likelihood or the risk occurring and/or its potential impact.

Table 12: Potential risks, impacts and mitigation measures associated with the provision of mitigation water to Lake Yando

Risks/limiting factors	Impacts	Mitigation measures
Inappropriate mitigation water calculations	Loss of high environmental values and inability to achieve objectives and goal	Review the mitigation water recommendations in 2012
Opportunistic diversion licences (equating to approximately 120 ML)[#]	Artificial lowering of water level threatening achievement of identified objectives and goal. Using environmental and mitigation water for consumptive use.	Investigate options for alternative supply Review licence conditions
Ineffective delivery	Inability to deliver water in order to achieve objectives and water management goal	Ensure that the delivery capacity is sufficient to facilitate delivery of required volumes at critical times (e.g. delivery share).
Future NVIRP actions inhibit significant leakage and seepage loss contributions	Loss of high environmental values. Failure to achieve identified objectives and water management goal	If future actions are likely to impact seepage and leakage loss contributions (i.e. lining or decommissioning any channels within 200 m of the wetland) detailed analysis of the loss contributions is required and incorporated into the mitigation water recommendations.
Delivery of mitigation water causes adverse impacts on habitat, surrounding land, etc	Adverse impacts may result from delivery of mitigation water e.g. Flooding of adjacent land, fluctuations in turbidity and salinity.	Build management and delivery of mitigation water into environmental water management framework

[#] G-MW stage 5 roster suspensions on diversions are currently in place. These are to remain in place, or appropriate restrictions implemented if not already in place, to ensure that any mitigation water delivered to wetlands and waterways is protected until such time more permanent measures are established. The roster suspensions may be temporarily lifted to allow extraction to occur where there are demonstrable alternative water supplies entering the waterway or wetland (e.g. as a result of flood).

7. Water delivery arrangements

Lake Yando receives outfalls from the Pyramid-Boort channel 5/2 via a fully automated regulator and delivery channel approximately 700 m in length (Figure 8). Following recent upgrade works the capacity of the channel and delivery channel is 35 ML/day while the automated regulator has a capacity of 60 ML/day.

The storage capacity of Lake Yando is determined by the overflow sill on its northeast margin, sitting at 87.59 m AHD (Price Merrett Consulting 2006).

At a rate of 35 ML/day (capacity following recent infrastructure upgrade works), Lake Yando can be filled in approximately 14 days (assuming no losses and adequate capacity is available in channel 5/2).

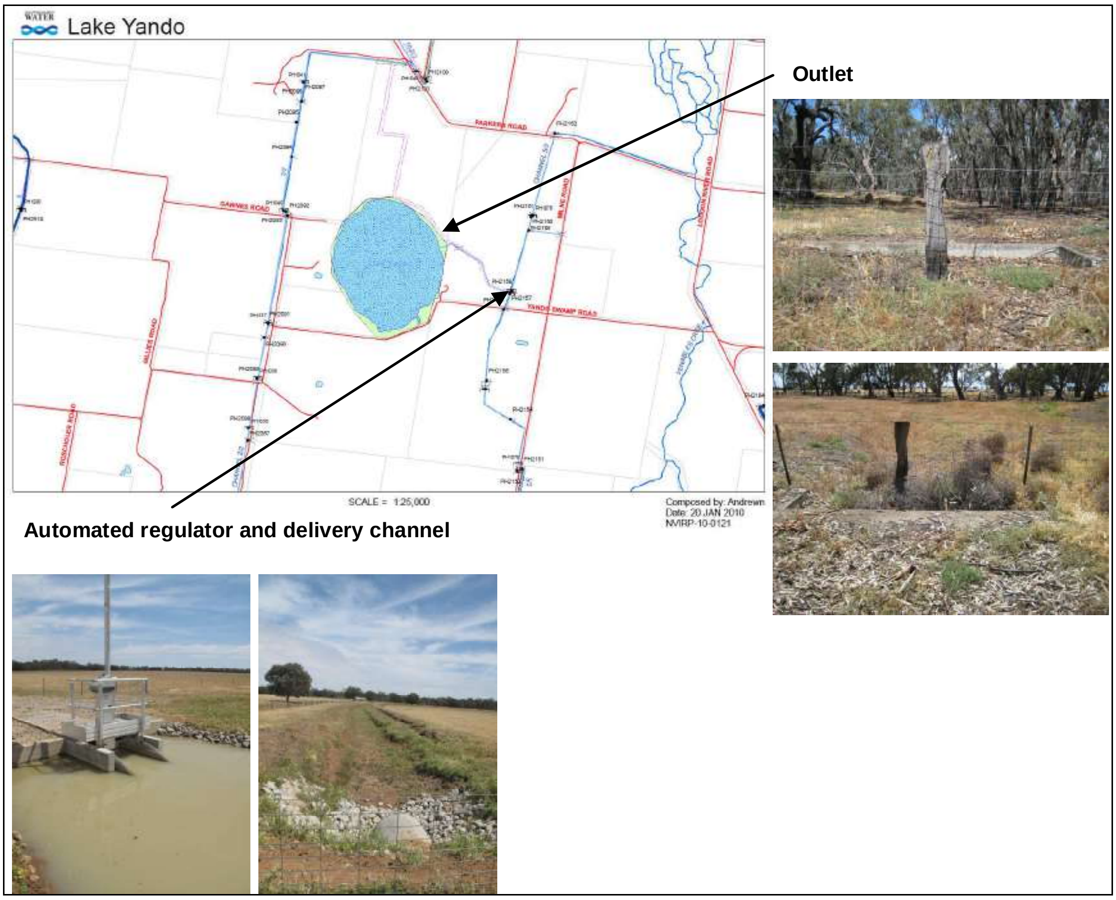


Figure 8: Lake Yando infrastructure

7.1. NVIRP works program – channel 5/2

The Stage 1 NVIRP works program includes delivering an automated backbone for the water distribution system, rationalising spur channels, connecting farm water supply to the backbone and upgrading metering on up to 50% of customer supply points in the GMID.

The Pyramid-Boort channel 5/2, on which the Lake Yando outfall structure is located, is the backbone within the vicinity of Lake Yando; however approximately 1.7 km of the channel (south of the automated regulator delivering water to lake Yando) may be considered for rationalisation as part of the NVIRP Connections Program. It is recommended that channel 5/2 is retained to ensure Lake Yando is able to receive environmental water or suitable alternative supply arrangements are agreed to.

NVIRP are responsible for “retain(ing) infrastructure and improving where practicable, where it will be required for delivering environmental water….” (NVIRP 2010). A review of the infrastructure requirements and supply arrangements will need to be undertaken if channel 5/2 is considered for rationalisation. Similarly, the potential impact of providing a new supply point will need to be investigated if the current supply point is likely to alter.

7.2. Infrastructure requirements

At present, Lake Yando is supplied via a fully automated regulator and delivery channel with capacities of 60 ML/day and 35 ML/day, respectively. At a rate of 35 ML/day, Lake Yando is able to be filled in 14 days (assuming no losses and adequate capacity is available in channel 5/2).

The current delivery infrastructure is considered adequate to deliver the desired water regime and no infrastructure upgrades are recommended as part of NVIRP.

8. Adaptive management framework

A key NVIRP principle is that an adaptive management approach is adopted to ensure an appropriate response to changing conditions.

Adaptive management is a continuous management cycle of assessment and design, implementation, monitoring, review and adjustment. Table 13 shows how the adaptive management approach will be applied in the context of this EWP.

Table 13: Adaptive management framework

Adaptive management phase	Application to this EWP (Responsible agency)	When
Assessment and design	Assessment identifies environmental values, their water dependencies, and the potential role of incidental water. Design determines the desired water regime to support environmental values and determines any mitigation water commitment. Details of both these phases are documented in this EWP. (NVIRP)	2010
Implementation	Implementation is the active management of environmental water, of which mitigation water may form a portion, consistent with this EWP. (Agencies as appropriate)	Continuous
Monitoring (and reporting)	Monitoring is gathering relevant information to facilitate review and enable any reporting obligations to be met. Two types of monitoring are required. Compliance monitoring is checking that the intended water regime is applied. Performance monitoring is used to inform the review of the effectiveness of the interim mitigation water contribution to achieving the water management goal. (NVIRP – to resource or coordinate monitoring to meet its reporting obligations; other agencies – monitoring to inform assessment of achievement of environmental objectives).	Annual
Review	Review is evaluating actual results against objectives and identifying any improvement opportunities which may be needed. (NVIRP, until responsibilities transferred to other agencies)	2012, 2015, 2020, 2025, etc
Adjustment	Adjustment is determining whether changes are required following review or after considering any new information or scientific knowledge and making any design changes in an updated version of the EWP. (NVIRP, until responsibilities transferred to other agencies)	2012, 2015, 2020, 2025, etc

8.1. Monitoring and reporting

Mitigation water is not currently recommended for Lake Yando, therefore there is no requirement for NVIRP to report, annually, on the contribution, or provision, of “NVIRP Mitigation Water” towards achieving the water regime as with other EWPs.

It is expected that the environmental water holder will monitor environmental water delivery (i.e. quantity, timing, duration and frequency) and implement a detailed monitoring program to enable assessment of ecological condition. NVIRP will not implement a detailed monitoring program.

It is beyond the scope of this EWP to provide a detailed monitoring program to determine the effectiveness of the desired water regime in achieving ecological objectives and the water management goal. However, Appendix J provides some suggested components identified during the preparation of this EWP to be considered in preparing a monitoring program for the wetland.

The recommendations within this EWP (including the requirement of mitigation water and reporting) will be regularly reviewed as outlined in Section 8.2.

8.2. Review

Periodic reviews provide the opportunity to evaluate monitoring results in terms of compliance, ecological objectives and to learn from implementation.

It is expected this EWP will be reviewed in 2012, 2015, 2020 and every five years thereafter, or at any time, if requested by the Victorian Minister for Water or Commonwealth Minister for Environment Protection.

8.3. Adjustment

Adjustments may be made to:

- operational management
- management hypotheses and, perhaps, to ecological objectives
- cope with unexpected issues.

These adjustments will be incorporated into the EWP.

9. Governance arrangements

A summary of the roles and responsibilities of the various bodies relating to the delivery and review of management and mitigation measures is provided in Table 14 (NVIRP 2010). The table outlines the roles and responsibilities before and during the implementation of NVIRP in the modified GMID.

Table 14: Roles and responsibilities

Agency	Assess and develop management and mitigation measures	Deliver and review management and mitigation measures during NVIRP implementation
NVIRP	• identify and account for water savings, subject to audit by DSE accredited auditor • Lead the assessment and development processes for management and mitigation measures including developing and gaining approval to the WCMF (which guides the development of EWPs and the assessment of mitigation water). • Maintain short-list of all wetlands, waterways and groundwater dependent ecosystems for mitigation. • Identify and source mitigation water required to implement management and mitigation measures including the adaptive development of EWPs. • Retain or provide infrastructure to deliver water to wetlands and waterways. • Convene and chair the Technical Advisory Committee. • Convene the Expert Review Panel	• Apply, review and, as necessary, develop amendments and gain approval to updated versions of the WCMF. • Provides resources to enable monitoring and review of management and mitigation measures • Establish protocols for transfer of responsibility to relevant agencies. • Coordinate with other agencies to improve management and mitigation measures. • Arrange for the provision of delivery and measurement infrastructure including capacity and operational flexibility for mitigation water • Work closely with system operator.
Catchment Management Authority	• Identify and inform NVIRP of opportunities for best practice. • Inform NVIRP of its infrastructure requirements to deliver environmental water. • Participate in Technical Advisory Committee. • Agree to implementing relevant components of Environmental Watering Plans.	• Advise Environmental Water Holder and system operator on priorities for use of environmental entitlements (including mitigation water) in line with recommendations outlined in the EWPs • Implement the relevant components of Environmental Watering Plans. • Operate, maintain and replace, as agreed, the infrastructure required for delivery of mitigation water, where the infrastructure is not part of the G-

Agency	Assess and develop management and mitigation measures	Deliver and review management and mitigation measures during NVIRP implementation
	• Agree to implementing other relevant regional management and mitigation measures required due to the implementation of NVIRP.	MW irrigation delivery system. • Report on environmental outcomes (e.g. wetland or waterway condition) from the delivery of the water, in the course of normal reporting on catchment condition. • Where agreed conduct the periodic review of EWPs and report results to NVIRP. • Manage and report on other relevant catchment management and mitigation measures required due to the implementation of NVIRP.
Land Manager (Public and private as relevant)	• Identify and inform NVIRP of opportunities for best practice. • Participate in Technical Advisory Committee. • Agree to implement relevant components of Environmental Watering Plans. • Agree to implement other relevant regional management and mitigation measures required due to the implementation of NVIRP.	• Implement the relevant components of Environmental Watering Plans. • Operate, maintain and replace, as agreed, the infrastructure required for delivery of mitigation water, where the infrastructure is not part of the G-MW irrigation delivery system. • Where agreed, participate in the periodic review of relevant EWPs. • Manage and report on other relevant catchment management and mitigation measures required due to the implementation of NVIRP.
System Operator	• Identify and inform NVIRP of opportunities for best practice. • Participate in Technical Advisory Committee. • Agree to implement relevant components of Environmental Watering Plans. • Administer management and operational arrangements.	• Implement the relevant components of Environmental Watering Plans, namely delivery of mitigation water. • Operate, maintain and replace, as needed, the infrastructure required for delivery of mitigation, or other, water, where the infrastructure is part of the G-MW irrigation delivery system. • May negotiate transfer of ownership of infrastructure to the environmental water/land manager for provision of mitigation water if it is no longer required for the public distribution system, in accordance with the principles set out in section 9. • Where the infrastructure assets are due for renewal or refurbishment, the water corporation will undertake the upgrade to the best environmental practice, including any requirements to better provide Environmental Water Reserve.

Agency	Assess and develop management and mitigation measures	Deliver and review management and mitigation measures during NVIRP implementation
		• Report annually on the availability and delivery of water for mitigating environmental impacts as part of reporting upon meeting obligations under its bulk entitlement. In some instances, it will be appropriate to measure mitigation flows to ensure mitigation volumes of water are delivered. • Work closely with NVIRP

DSE	• Identify and inform NVIRP of opportunities for best practice.
	• Participate in Technical Advisory Committee.
	• Arrange funding to enable environmental water manager, catchment manager and land manager to deliver agreed measures.
	• Develop policies to address relevant issues (assuming that other agencies will participate in policy development).
		• Participate in the periodic review of the Water Change Management Framework and relevant EWPs.
		• Conduct review as part of the long-term water resource management; a requirement specified in Section 22L of the *Water Act 1989*. The process will allow:
		  - the balance of the environmental obligations and consumptive water to be assessed and restored based on certain conditions
		  - the need for the obligation reviewed based on the environmental values at the time of the review.

Environmental Water Holder (to be established) **DSE pending appointment of the Environmental Water Holder**	Environmental Water Holder not yet in place. Role fulfilled by DSE in the meantime.	• Hold and manage environmental entitlements, including mitigation water that becomes a defined entitlement. • Consult with CMAs in identifying priority wetlands, waterways and groundwater systems for environmental watering. Plan and report on the use of environmental entitlements. • Participate in the periodic review of relevant EWPs. • Negotiate with Commonwealth Environmental Water Holder to arrange delivery of Commonwealth environmental water.

9.1. Framework for operational management

The obligation to annually reserve and supply mitigation water, will be established in one of two ways:

- by amendment to the River Murray and Goulburn System Bulk Entitlements held by G-MW; or
- by agreement (contract) between the Minister for Environment and G-MW, under section 124(7) of the *Water Act 1989*.

Both arrangements are legally binding and reflect the commitments of the Northern Victoria Irrigation Renewal Project to provide water to mitigate potential impacts to high value environmental assets. The arrangements require G-MW to set aside water in the Goulburn and Murray Systems to meet the mitigation water needs, calculated in accordance with the methods in the Water Change Management Framework, for future use at wetlands and waterways that have an approved environmental watering plan.

Mitigation water will be able to be carried over in line with other entitlements and will only be supplied to those wetlands where a mitigation water requirement has been identified. The specification of the volume and use of mitigation water will be the same regardless of whether it is established via bulk entitlement or contract. There is no mitigation water recommended for Lake Yando, however the environmental water manager will need to provide information into the review of this EWP, as outlined in Section 8.2.

Delivery of environmental water to Lake Yando requires the coordination of information, planning and monitoring among a number of agencies.

A framework for operational management outlining the relevant roles and responsibilities is presented in Figure 9. This has been developed to describe the decision-making process required to coordinate implementation of the desired water regime for Lake Yando. The various government bodies and their roles will change over time, in particular with the establishment of the Victorian Environmental Water Holder. Therefore, this framework should be taken as a guide only.

The main components are:

- assessment of current conditions i.e. wetland phase, climatic conditions, etc.
- identification of potential water sources and preparation of relevant information for submission of water bid
- coordination of the environmental water delivery and adaptive management process.

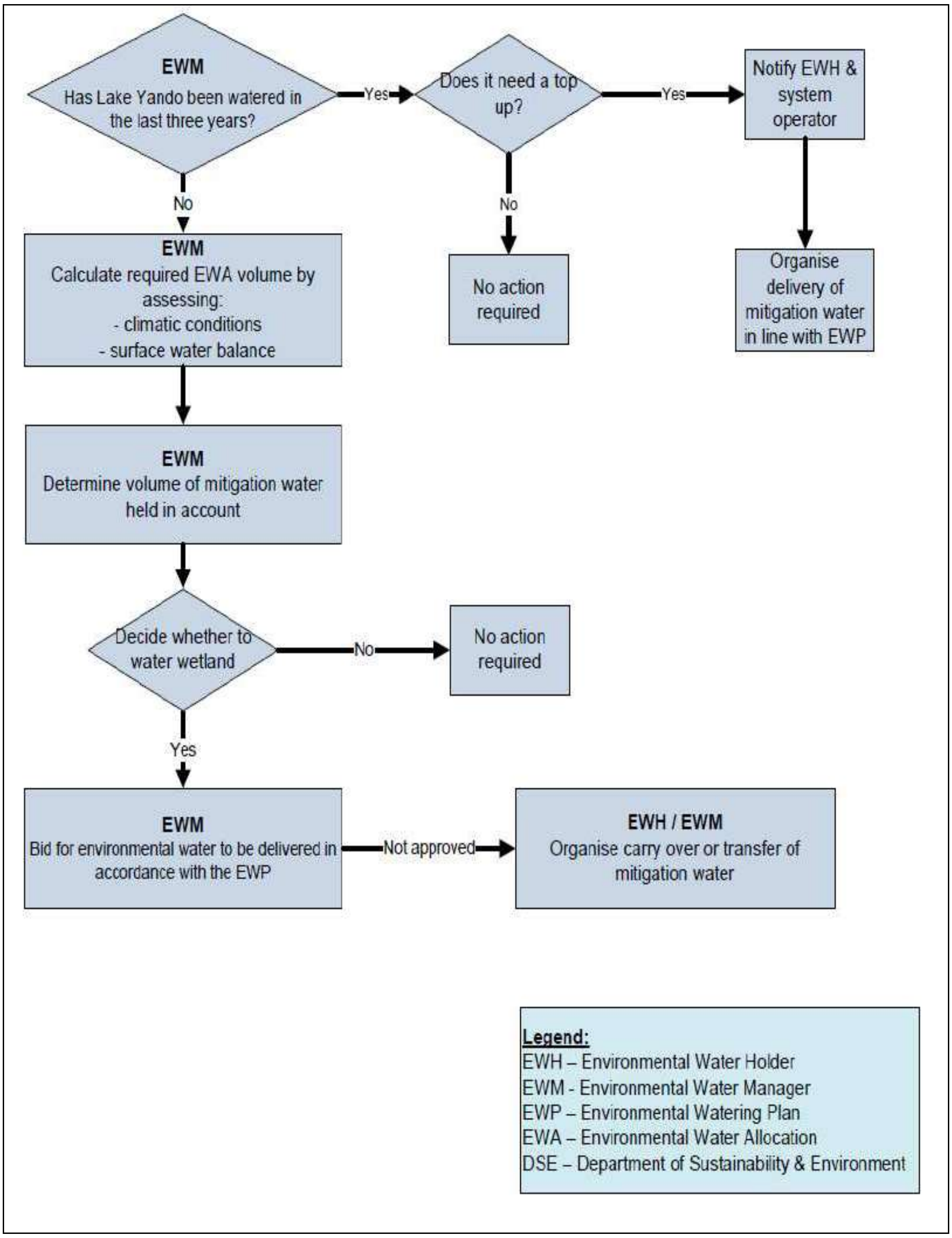


Figure 9: Operational management framework

10. Knowledge gaps

The Lake Yando EWP 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 EWP. These are summarised below.

10.1. Works program

- The NVIRP works program in the vicinity of Lake Yando needs to be confirmed to more specifically assess the potential impacts on the wetland. In particular, the Pyramid-Boort channel 5/2 is currently identified as the backbone in the vicinity of Lake Yando; however approximately 1.7 km from the automated regulator feeding Lake Yando may be considered for rationalisation as part of NVIRP's connections program.

10.2. Lake Yando

- The requirements Winged Water-starwort are largely unknown. Advances in research and understanding of the species requirements needs to inform the adaptive management of this EWP and desired water regime as it comes to hand.
- Continued monitoring and evaluation of groundwater and surface water data is recommended to ensure no detrimental impacts from implementation of the water regime (Appendix J).
- The relationships between hydrology and ecological response in wetlands are complex. Therefore, it will be important that monitoring and adaptive management is

10.3. Roles and responsibilities

The roles and responsibilities of key agencies in the operational management of mitigation water (and other sources of environmental water) have not yet been clearly defined. A process has been recommended (Section 9.1). However, in light of changes recommended in the Northern Region Sustainable Water Strategy (Victorian Environmental Water Holder) and the Land and Biodiversity White Paper, roles and responsibilities will need to be reviewed

11. References

Baldwin, D. S., Nielsen, D. L., Bowen, P. M. and 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 (2010). *Hydrogeological overview – Lake Yando*, Prepared for the North Central Catchment Management Authority, Bartley Consulting, Heidelberg, Victoria

Boulton, A. J. and Brock, M. A (1999). *Australian Freshwater Ecology: Processes and management,* Gleneagles Publishing, Glen Ormond, South Australia

Bureau of Meteorology (2009). *Climate Statistics for Boort*, Australian Government [online] available: http://www.bom.gov.au/climate/averages/tables/cw_080002.shtml [accessed: November 2009], Canberra

Campbell, E., Cooling, M. and Hogan, R. (2005). *Ecological accountability in Gunbower Forest*. Paper for International River Symposium, Brisbane.

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

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.

DEWHA (2009). *Environment Protection and Biodiversity Conservation Act*, Department of the Environment, Water, Heritage and the Arts, Canberra, Australian Capital Territory, Available at: www.environment.gov.au, Accessed: November 2009

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*, Department of Natural Resources and Environment, Melbourne, Victoria.

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

DPCD (2009). *Environment Assessment Referrals from July 2008 - June 2009*. Available at: http://www.dse.vic.gov.au/DSE/nrenpl.nsf/LinkView/E6DAFE581144D1FFCA25757B0008A28314CD70100E11BFB5CA2572DA007FAA9C, Accessed: November 2009

DPCD (2007). *General Practice Note The Aboriginal Heritage Act 2006 and the Planning Permit Process* July 2007 (Revised October 2007), the Department of Planning and Community Development, Melbourne.

DPI and HydroEnvironmental (2007). *Irrigation Drainage Memorandum of Understanding Decision Support System: Assumptions for Management Actions – North Central Catchment,* Prepared by Brian Holmes, Department of Primary Industries, Kerang.

DSE (2009a). *Biodiversity Interactive Map*. Department of Sustainability and Environment http://mapshare2.dse.vic.gov.au/MapShare2EXT/imf.jsp?site=bim (Accessed November 2009)

DSE (2009b). 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 (2009c). *Victorian Government Response to: Victorian Environmental Assessment Council's River Red Gum Forests Investigation*, Final Report, Victorian Government, March, Melbourne.

DSE (2009d). *Flora and Fauna Guarantee Act 1988 Protected Flora List* July 2009, The Department of Sustainability and Environment, Melbourne.

DSE (2009e). Data Source: '1750_EVC , © 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 (2009f). Data Source: '2005_EVC', © 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 (2009g). 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: February 2010.

DSE (2009h). *Water Savings Protocol Technical Manual for the Quantification of Water Savings Final Version 1.0,* Department of Sustainability and Environment, Melbourne Victoria

DSE (2008a) *Northern Victoria Irrigation Renewal Project – Suggested principles & processes for compliance with environmental obligations,* Compiled by Andrea Ballinger, Department of Sustainability and Environment, Melbourne.

DSE (2008b) *Northern Region: Sustainable Water Strategy.* Department of Sustainability and Environment, Melbourne.

DSE (2007a). *Advisory List of Threatened Vertebrate Fauna in Victoria,* Department of Sustainability and Environment, Victoria.

DSE (2007b). *Native Vegetation Information: Overview of Native Vegetation Spatial Datasets Information Sheet No. 1*. Department of Sustainability and Environment, East Melbourne, Victoria.

DSE (2006). *Murray Flora and Fauna Entitlement: Annual Distribution Program 2006/2007*, Compiled by Andrea Joyce, Department of Sustainability and Environment, October, Melbourne.

DSE (2005a). *Advisory List of Rare or Threatened Plants in Victoria*, Department of Sustainability and Environment, Victoria.

DSE (2005b). *Index of Wetland Condition: Conceptual Framework and Selection of Measures*. Department of Sustainability and Environment, Victoria.

Ecos Environmental Consulting (2007). *Boort District Wetlands Vegetation Assessment.* Report prepared for the North Central Catchment Management Authority. Ecos Environmental Consulting Pty Ltd, North Balwyn, Victoria

Gippel, C.G. (2010). *Comments on Application of SWET Water Balance Model to Terminal Wetlands_V1.* Prepared by Dr. Chris Gippel, Fluvial Systems Pty Ltd, Stockton, NSW

Gippel, C. J. (2005a). *Operational procedure to calculate water recovery from wetlands and lakes at the source (individual wetlands).* Fluvial Systems Pty Ltd, Stockton, NSW. The Living Murray, Murray-Darling Basin Commission, Canberra, Australian Capital Territory.

Gippel, C. J. (2005b). *Model to calculate water recovery from wetlands and lakes at the source (individual wetlands) – Example application to Euston Lakes and Edward Gulpa wetlands.* Fluvial Systems Pty Ltd, Stockton, NSW. The Living Murray, Murray-Darling Basin Commission, Canberra, Australian Capital Territory.

Gippel, C. J. (2005c). *SWET (Savings at Wetlands from Evapotranspiration daily Time-Series)*. *A model to calculate water recovery from wetlands and lakes at the source (individual wetlands). Model Manual.* Fluvial Systems Pty Ltd, Stockton, NSW. The Living Murray, Murray-Darling Basin Commission, Canberra, Australian Capital Territory.

G-MW (2008a). *G-MW Murray Strategic Monitoring Project*, Goulburn-Murray Water, Shepparton.

G-MW (2008b). *Environmental Water Allocations - Calculations for the SIRTEC*, Agenda Paper Compiled by Sam Green and Mary Shi, Tatura

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

LCC (1988). *Statewide Assessment of Public Land Use*, Land Conservation Council, July, Melbourne, Victoria

Lugg, A., Heron, A., O'Donnell, T. and 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

McJannet, D.L., Webster, I.T., Stenson, M.P. and Sherman, B.S. (2008). *Estimating Open Water evaporation for the Murray Darling Basin.* A Report to the Australian Government from the CSIRO Murray-Darling Basin Sustainable Yields Project. CSIRO, Australia. Available at: www.clw.csiro.au

NCCMA (2008). *2008/2009 Annual Watering Plan: Bulk Entitlement*, (Loddon River Environmental Reserve) Order 2005. Final Draft. NCCMA, Huntly, Victoria.

NCCMA (2005). *Wetlands Background Paper,* 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. and 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.

Price Merrett Consulting (2006). *Lake Yando Contour Survey*. Prepared for the North Central Catchment Management Authority. Price Merrett Consulting, Kerang, Victoria.

Saddlier, S., O'Connor, J., Brown, G. and Loyn, R. (2009). *Northern Victorian Irrigation Renewal Project Threatened Species – Expert Comment*, prepared by Arthur Rylah Institute for Environmental Research, Department of Sustainability and Environment, Victoria.

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

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

Walsh, N.G. and Entwistle, T.J. (1999) *Flora of Victoria: Volume 4 Dicotyledons (Cornacaea to Asteraceae)*. Inkata Press, Melbourne.

Appendix A: NVIRP TAC and Wetland workshop participants

Table A1: NVIRP TAC members

Name	Organisation and Job title
Anne Graesser	Manager – Natural Resources Services Goulburn Murray Water
Carl Walters	Executive Officer SIR Goulburn Broken CMA
Emer Campbell	Manager – NRM Strategy North Central CMA
Jen Pagon	Catchment and Ecosystem Services Team Leader Department of Primary Industries
John Cooke	Manager Sunraysia Department of Sustainability and Environment
Ross Plunkett	Executive Manager Planning NVIRP
Tamara Boyd	State Parks and Environmental Water Coordinator Parks Victoria
Observers	
Andrea Joyce	Program Leader – Wetlands and Environmental Flows Department of Sustainability and Environment
Bruce Wehner	Ranger Parks Victoria
Caroline Walker	Executive Assistant to Executive Manager Planning NVIRP
Chris Solum	Environmental Program Manager NVIRP
Michelle Bills	Strategic Environmental Coordinator North Central CMA
Pat Feehan	Consultant Feehan Consulting
Paulo Lay	Senior Policy Officer Department of Sustainability and Environment
Rebecca Lillie	Project Officer North Central CMA

Table A2: Wetland workshop participants – 25 February 2010

Name	Organisation and Job title
Andrea Joyce	Program Leader – Wetlands and Environmental Flows Department of Sustainability and Environment
Bridie Velik-Lord	Environmental Flows Officer North Central CMA
Cherie Campbell	Senior Ecologist Murray Darling Freshwater Research Centre
Chris Solum	Environmental Program Manager NVIRP
Emer Campbell	Manager NRM Strategy
Geoff Sainty	Wetland Specialist Sainty and Associates Pty Ltd
Karen Weaver	Biodiversity and Ecosystem Services Department of Sustainability and Environment
Lyndall Rowley	Research and Development Project Officer North Central CMA
Mark Tscharke	Senior Ranger Parks Victoria
Pat Feehan	Consultant Feehan Consulting
Rebecca Lillie	Project Officer North Central CMA
Rob O'Brien	Senior Environmental Officer Department of Primary Industries
Shelley Heron	Manager – Water Ecosystems Kellogg Brown and Root

Appendix B: Community Interaction/Engagement

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 each 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 Yando)

- Marg Piccoli (landholder)
- Rod Stringer (landholder)
- Lawrence Cameron (G-MW and former landholder)
- Paul Haw (community member)

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?*

Pre European Settlement Condition

- Seasonal, intermittent Red Gum Swamp.
- Filled and flushed when Loddon River floodwater fanned out across the floodplain.
- The Loddon River floodplain and its wetlands experienced highly variable rainfall and flooding conditions.
- Lake Yando functioned as a deeper section within a complex interconnecting creek system.
- Floodwater overflowed out of the wetland in a northerly direction at different locations and widths, at different flood levels.
- The wetland was not deep and there is no formed lunette on the eastern side.
- The Swamp only held water for several months after a flood event always drying out regularly.
- Lake Yando was well connected to a creek and floodplain system where wide corridors of native vegetation linked provided opportunity for native fauna to move throughout the floodplain area.
- The wetland supported large widely spaced Red Gums across the lake floor.
- The archeological sites present at Lake Yando confirm it was an environmentally productive system that provided food and other resources to Aboriginal People.
- The wetland would have contained a greater diversity of native plants, insects and animals than what is present today

Changed Management

- Lake Yando and the broader floodplain area were impacted dramatically as part of European Settlement.

- Grazing of hard hoofed domestic livestock put significant pressure on the native plants, altered the soil conditions and displaced native fauna.
- The Loddon River Floods were manipulated to suit European settlers and this changed water regime altering the districts waterways and wetlands.
- Heavy grazing of livestock diminished native plant cover and extinction of the more palatable species was likely in the mid 1800's.
- Some of the large Red Gums may have initially died from excessive flooding in the 1860's and onwards. The influence of "Black Fellows Cutting" at Fernihurst was significant in pushing additional floodwater through the Boort wetlands.
- Levees constructed on the floodplain channel the water through the creek lines and waterways and prevented the natural spread or sheet flooding of the area.
- William Haw operated a Saw Mill in the bed of Lake Yando.
- The development of the irrigation supply system resulted in Lake Yando receiving significant channel outfall quantities.
- In the 1960's some people wanted to keep Lake Yando full to maintain the high Ibis numbers while other wanted it to dry out to reduce the salinity impact.
- Lake Yando has remained in good condition, despite excessive flooding due to it being a shallow wetland and still periodically drying out.
- The healthy Red Gums on the eastern side of the wetland have been encouraged by a long history of GMW channel outfalls.
- Channel outfalls have significantly been reduced, particularly over the past 10 to 15 years and are currently insignificant.
- Irrigation tail water flowing off surrounding irrigated farmland and entered the wetland throughout the irrigation system.
- Irrigation tail water runoff into the wetland has completely ceased as irrigation and efficiency have improved.
- GMW has occasionally outfall reasonable quantities of water, to the eastern side of the reserve, as part of draining down the irrigation supply system.
- Saline areas were appearing, particularly on the southeastern side during the wet period (1950's to 1990's).
- Over the past 10 years the watertables beneath Lake Yando have dropped significantly and are currently more than 5 m below the surface.
- Groundwater levels dropped about 3m from 2002 to 2010.
- Stock from the surrounding farmland frequently grazed and damaged the reserve, but minimal grazing occurs now.
- An annual pumping license of 120 ML was issued a long time ago (perhaps1950's?) but rarely ever used.
- In 1996 the sill of the overflow creek was lowered as part of the Boort West of Loddon Salinity Management Plan to slightly reduce its depth and improve the water regime and condition of the wetland.

Environmental Values

- The diversity and environmental values of Lake Yando were much higher before European settlement
- The wetter period after the 1950's resulted in more frequent flooding of the swamp and resulted in increased waterbird usage.
- The environmental condition of the creeklines and wetlands was still very good in the 1950's.
- During the wetter periods of the 1970's and 1980's Ibis roosted in large numbers at the swamp.
- Ibis breed at Lake Yando during the wetter periods when the swamp received more frequent and prolonged flooding.
- The deeper channeled sections along the eastern side of the wetland create variable water depths and increase the diversity of plants and animals that use the area.

- Ducks were the most prolific waterbirds that utilized the wetland.
- Heaps of waterbirds were present across all of the districts wetlands during the flood years of the 1950's.
- Lake Yando water levels were maintained mostly permanent in the 1970's and good numbers of Red Fin were present.
- Carp kills occurred when the wetland dried out after successive flooding.
- Less bird life now, compared to when it received more water.
- Commercial quantities of firewood have been removed from Lake Yando over the past 5 years, reducing its environmental value.
- Increased community interest in environmental protection.
- Another nearby private wetland "Loddon Park Swamp" also supported a good ibis rookery during wetter periods.
- Long extended dry periods will reduce understorey species and associated insect activity and diminish the food change.
- Avoid leaving the wetland dry for more than 5 years.

Suggested Future Management

- The land managers Parks rarely visit the reserve.
- The management of Lake Yando needs to be in context of the other environmental features within the area.
- Lake Yando will deteriorate if denied water for long periods.
- The wetland should not be left dry for over 10years.
- Ideal water regime should be around 1 in 3 years although floods may dictate this.
- It is important that the wetland be allowed to dry out frequently.
- Flooding frequency needs to maintain the aquatic plants such as Cumbungi and Phagmites as they are important components of the vegetation.
- Motorbikes currently enter and damage the reserve and these needs to be controlled.
- Firewood removal should be prevented as it threatens the environmental and cultural values of the reserve.

Key Points

- Lake Yando was an intermittent and shallow wetland that received water during a Loddon River flood event.
- In its natural condition it supported large widely spaced Red Gums across the lake bed and a range of aquatics that were adapted to variable climatic conditions.
- The aboriginal cultural sites present at the wetland are evidence that this wetland and connecting waterways were very productive.
- European settlement lead to the overgrazing of domestic livestock and changed water regimes.
- Lake Yando has developed new environmental values over the past 150 years and is still considered significant.
- Channel outfalls have contributed to the water regime and the more recently developed environmental values.
- The wetland is naturally shallow and regularly dries out even during successive floods.
- Extended dry periods of 5 to 10 years, without flooding, will result in loss of environmental values.
- The ideal water regime is 1 in 3 years flooding however this needs to be considered in the wider floodplain context and natural flooding will influence this also.
- There is a need to deter motorbikes, 4WD's and firewood collection to protect the environmental and cultural values of the reserve.

Appendix C: Contour Plan and Capacity Table
Price Merrett Consulting (2006)

REV	DATE	ORIGINAL CREATED	DRN	CHKD
		REVISIONS		

JOB DETAILS

DESIGNED :
DRAWN : R.J.MACLEAN
SURVEY DATE : 25/07/2006
DATUM : A.H.D.
GRID INTERVAL : RANDOM
LEVEL BOOK :
FIELD BOOK : F022 & F026

SCALE OF METRES

30 0 60 120

ORIGINAL DRAWING SCALE
1 IN 3000 (A2 SHEET SIZE)

MGA ZONE 54

PRICE MERRETT GROUP

Price Merrett Consulting Pty.Ltd.
CONSULTING SURVEYORS, ENGINEERS, IRRIGATION DESIGNERS

P.O. BOX 313
KERANG VIC. 3579
Ph. (03) 5452 2490
FAX (03) 5452 2566
EMAIL- pmc@pricemerrett.com.au

P.O. BOX 1172
SWAN HILL VIC. 3585
Ph. (03) 5032 3685
FAX (03) 5032 2472
EMAIL- pmash@pricemerrett.com.au

292 GEORGE STREET
DENILIQUIN NSW 2710
Ph. (03) 5881 5937
FAX (03) 5881 1399
EMAIL- pmc@pricemerrett.com.au

NORTH CENTRAL CATCHMENT MANAGEMENT AUTHORITY

LAKE YANDO CONTOUR SURVEY

HUNTLY

CROWN ALLOTMENT	SECTION	PARISH	FILE NUMBER	SHEET NUMBER	DRAWING No.	REVISION	SHEET SIZE
		BOORT	F3958	1 of 1	2177	0	A2

LAKE YANDO

RATING CURVE TABLE

ELEVATION AHD	SURFACE AREA (Ha)	VOLUME STORED (MEGALITRES)	
86.40	0.420	0.24	
86.50	1.072	0.96	
86.60	2.208	2.54	
86.70	4.353	5.69	
86.80	8.442	11.93	
86.90	17.271	24.18	HIGH WATER MARK ON GUAGE
87.00	32.163	48.45	
87.10	51.590	90.44	
87.20	62.501	148.39	
87.30	67.995	213.63	
87.40	72.880	284.20	
87.50	75.755	358.60	
87.59	77.595	427.65	OUTFALL SILL ELEVATION
87.60	77.725	435.41	

Note - volumes are cumulative volumes

Appendix D: Wetland characteristics

Characteristics	Description
Wetland Name	Lake Yando
Wetland ID	7625 507077
Wetland Area	78 ha of an 86 ha wildlife reserve
Conservation Status	Bioregionally Important Wetland
Land Manager	State Wildlife Reserve
Surrounding Land Use	Mixed irrigated agriculture (pastures and crops)
Water Supply	Natural: Unnamed distributary of Venables Creek Current: Pyramid-Boort Irrigation System: Channel Outfall (5/2) and environmental allocations • Delivery channel capacity: 35 ML/day • Automated regulator capacity: 60 ML/day • Average delivery rate 35 ML/day (approx. 14 days to FSL)
1788 Wetland Classification	Category: Deep freshwater marsh Sub-category: n/a
1994 Wetland Classification	Category: Deep Freshwater Marsh Sub-categories: Reed, Red Gum and Open Water
Wetland Capacity	478 ML, *FSL 87.59 m AHD* (Price Merrett Consulting 2006)
Outfall Volumes	4 ML (04/05) 28 ML (97/98 to 08/09 average)

Appendix E: Flora and fauna species list

Compiled: September 2009

Sources:

Campbell *et al*. (2009)

DSE (2009a)

Ecos Environmental Consulting (2007)

Saddlier *et al.* (2009)

Data Source: 'Threatened Fauna 100' © The State of Victoria, Department of Sustainability and Environment.

Data Source: 'Threatened Flora 100' © The State of Victoria, Department of Sustainability and Environment.

Data Source: 'Aquatic Fauna Database', Copyright - The State of Victoria, Department of Sustainability and Environment.

Common Name	Scientific Name	International Treaty	EPBC status	FFG status	DSE status
Fauna - native					
Australasian Grebe	*Tachybaptus novaehollandiae*				
Australasian Shoveler	*Anas rhynchotis*				VU
Australian Magpie	*Gymnorhina tibicen*				
Australian Pelican	*Pelecanus conspicillatus*				
Australian Raven	*Corvus coronoides*				
Australian Shelduck	*Tadorna tadornoides*				
Australian White Ibis	*Threskiornis molucca*				
Australian Wood Duck	*Chenonetta jubata*				
Bearded Dragon	*Pogona barbata*			DD	
Black Kite	*Milvus migrans*				
Black Swan	*Cygnus atratus*				
Black-faced Cuckoo-shrike	*Coracina novaehollandiae*				
Black-fronted Dotterel	*Elseyornis melanops*				
Black-shouldered Kite	*Elanus axillaris*				
Black-tailed Native-hen	*Gallinula ventralis*				
Black-winged Stilt	*Himantopus himantopus*				
Blue-billed Duck	*Oxyura australis*			L	EN
Brown Treecreeper (south-eastern ssp.)	*Climacteris picumnus victoriae*				NT
Carpet Python	*Morelia spilota metcalfei*		L	EN	
Chestnut Teal	*Anas castanea*				
Clamorous Reed Warbler	*Acrocephalus stentoreus*	B			
Cockatiel	*Nymphicus hollandicus*				
Common Greenshank	*Tringa nebularia*	B/C/J/R			

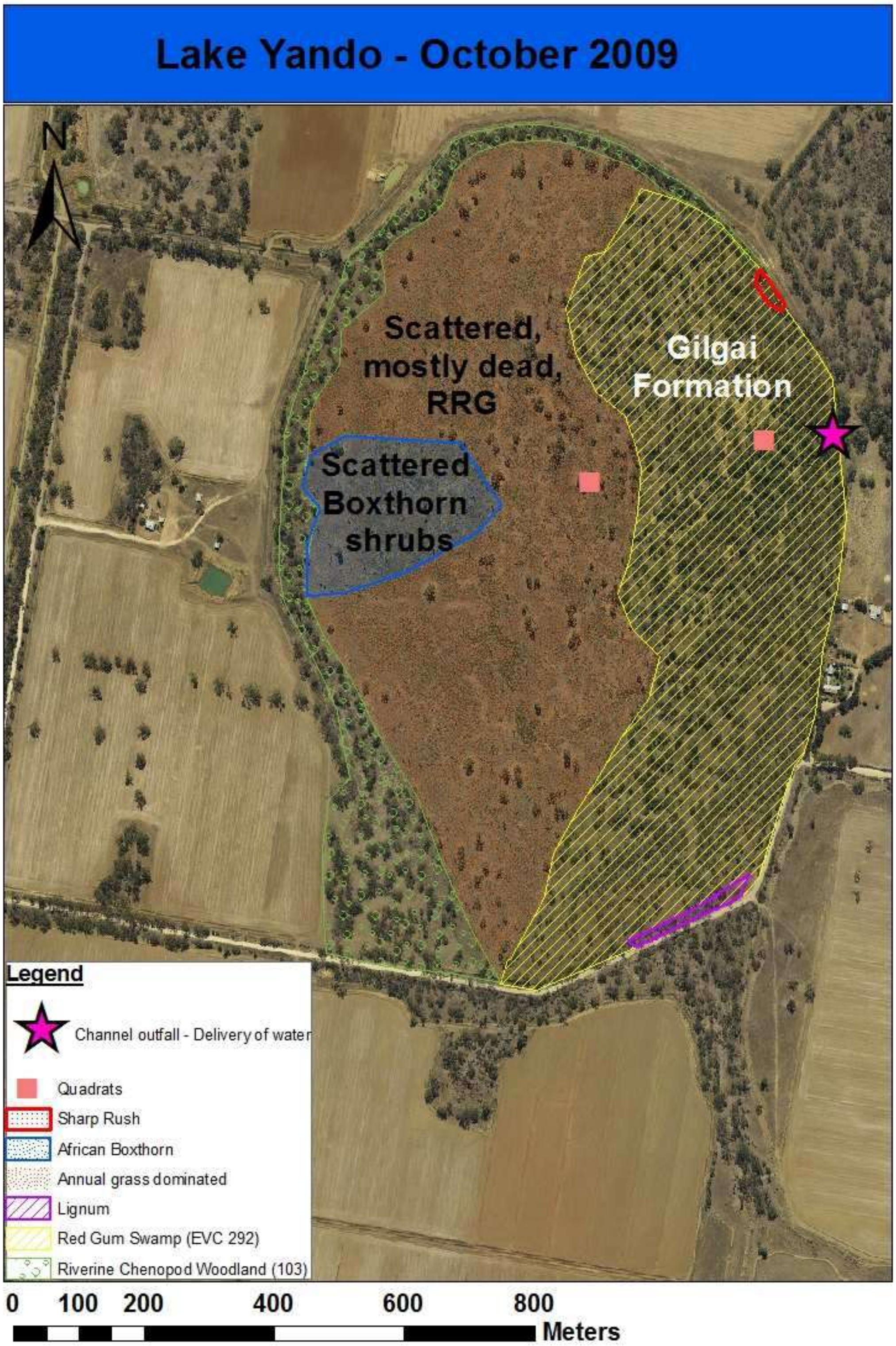
Common Name	Scientific Name	International Treaty	EPBC status	FFG status	DSE status
Common Long-necked Turtle	*Chelodina longicollis*				
Cotton Pygmy-goose	*Nettapus coromandelianus*				
Crested Pigeon	*Ocyphaps lophotes*				
Darter	*Anhinga novaehollandiae*				
Dusky Moorhen	*Gallinula tenebrosa*				
Dusky Woodswallow	*Artamus cyanopterus*				
Eastern Great Egret	*Ardea modesta*	C/J		L	VU
Eastern Rosella	*Platycercus eximius*				
Eurasian Coot	*Fulica atra*				
Freckled Duck	*Stictonetta naevosa*			L	EN
Freshwater Catfish	*Tandanus tandanus*		L	EN	
Galah	*Eolophus roseicapilla*				
Glossy Ibis	*Plegadis falcinellus*	B/C			NT
Golden Whistler	*Pachycephala pectoralis*				
Great Cormorant	*Phalacrocorax carbo*				
Great Crested Grebe	*Podiceps cristatus*				
Grey Shrike-thrush	*Colluricincla harmonica*				
Grey Teal	*Anas gracilis*				
Grey-crowned Babbler	*Pomatostomus temporalis*			L	EN
Hardhead	*Aythya australis*				VU
Hoary-headed Grebe	*Poliocephalus poliocephalus*				
Intermediate Egret	*Ardea intermedia*			L	CR
Lace Monitor	*Varanus varius*			VU	
Laughing Kookaburra	*Dacelo novaeguineae*				
Little Black Cormorant	*Phalacrocorax sulcirostris*				
Little Egret	*Egretta garzetta*			L	EN
Little Grassbird	*Megalurus gramineus*				
Little Pied Cormorant	*Microcarbo melanoleucos*				
Little Raven	*Corvus mellori*				
Magpie-lark	*Grallina cyanoleuca*				
Major Mitchell's Cockatoo	*Lophocroa leadbeateri*			L	VU
Masked Lapwing	*Vanellus miles*				
Murray Hardyhead	*Craterocephalus fluviatilis*	VU	L	CR	
Musk Duck	*Biziura lobata*				VU
Nankeen Kestrel	*Falco cenchroides*				
Noisy Miner	*Manorina melanocephala*				
Pacific Black Duck	*Anas superciliosa*				
Peaceful Dove	*Geopelia striata*				
Pink-eared Duck	*Malacorhynchus membranaceus*				
Purple Swamphen	*Porphyrio porphyrio*				
Rainbow Bee-eater	*Merops ornatus*	J			

Common Name	Scientific Name	International Treaty	EPBC status	FFG status	DSE status
Red-kneed Dotterell	*Erythrogonys cinctus*				
Red-necked Avocet	*Recurvirostra novaehollandiae*				
Red-rumped Parrot	*Psephotus haematonotus*				
Royal Spoonbill	*Platalea regia*				VU
Rufous Whistler	*Pachycephala rufiventris*				
Sacred Kingfisher	*Todiramphus sanctus*				
Silver Gull	*Chroicocephalus novaehollandiae*				
Spotted Marsh Frog (race unknown)	*Limnodynastes tasmaniensis*				
Straw-necked Ibis	*Threskiornis spinicollis*				
Striated Pardalote	*Pardalotus striatus*				
Striped Legless Lizard	*Delma impar*	VU	L	EN	
Superb Fairy-wren	*Malurus cyaneus*				
Swamp Harrier	*Circus approximans*				
Tree Martin	*Hirundo nigricans*				
Water Rat	*Hydromys chrysogaster*				
Wedge-tailed Eagle	*Aquila audax*				
Welcome Swallow	*Hirundo neoxena*				
Whiskered Tern	*Chlidonias hybridus*				NT
Whistling Kite	*Haliastur sphenurus*				
White-bellied Sea-Eagle	*Haliaeetus leucogaster*	C		L	VU
White-breasted Woodswallow	*Artamus leucorynchus*				
White-faced Heron	*Egretta novaehollandiae*				
White-necked Heron	*Ardea pacifica*				
White-plumed Honeyeater	*Lichenostomus penicillatus*				
Willie Wagtail	*Rhipidura leucophrys*				
Yellow-billed Spoonbill	*Platalea flavipes*				
Fauna - exotic					
Common Carp	*Cyprinus carpio*				
Common Starling	*Sturnus vulgaris*				
House Sparrow	*Passer domesticus*				
Redfin Perch	*Perca fluviatilis*				
Tench	*Tinca tinca*				
Flora - native					
Glaucous Goosefoot	*Chenopodium glaucum*				
Clammy Goosefoot	*Chenopodium pumilio*				
Cotula	*Cotula sp.*				
Common Spike-sedge	*Eleocharis acuta*				
Southern Cane-grass	*Eragrostis infecunda*				
Smooth Heliotrope	*Heliotropium curassavicum*				

Common Name	Scientific Name	International Treaty	EPBC status	FFG status	DSE status
Common Heliotrope	*Heliotropium europaeum*				
Poison Pratia	*Lobelia concolor*				
Common Nardoo	*Marsilea drummondii*				
Red Water-milfoil	*Myriophyllum verrucosum*				
Berry Saltbush	*Atriplex semibaccata*				
Saltbush	*Atriplex sp.*				
Brown-back Wallaby-grass	*Austrodanthonia duttoniana*				
Bristly Wallaby-grass	*Austrodanthonia setacea s.l.*				
Winged Water-starwort	*Callitriche umbonata*				r
Saloop	*Einardia hastata*				
Nodding Saltbush	*Einardia nutans ssp. nutans*				
Ruby Saltbush	*Enchylaena tomentosa var. tomentosa*				
River Red-gum	*Eucalyptus camaldulensis*				
Black box	*Eucalyptus largiflorens*				
Blackseed Glasswort	*Halosarcia pergranulata ssp. pergranulata*				
Peppercress	*Lepidium pseudohyssopifolium*				k
Tangled Lignum	*Muehlenbeckia florulenta*				
Spiny Lignum	*Muehlenbeckia horrida* subsp. *horrida*				
Jersey Cudweed	*Psuedognaphalium luteo-album*			P	
Hedge Saltbush	*Rhagodia spinescens*				
Prickly Saltwort	*Salsola tragus*				
Black Roly-Poly	*Sclerolaena muricata var. villosa*				
Copperburr	*Sclerolaena sp.*				
Narrow-leaf Cumbungi	*Typha domingensis*				
Broad-leaf Cumbungi	*Typha orientalis*				
Scrub Nettle	*Urticia incisa*				
New Holland Daisy	*Vittadinia sp.*			P	
	#177 Unknown herb				
Flora - exotic					
Aster-weed	*Aster subulatus*				
Hastate Orache	*Atriplex prostrata*				
Wild Oat	*Avena fatua*				
Oat	*Avena sp.*				
Great Brome	*Bromus diandrus*				
Madrid Brome	*Bromus madritensis*				
Red Brome	*Bromus rubens*				
Spear Thistle	*Cirsium vulgare*				
Drain Flat-sedge	*Cyperus eragrostis*				
Stinkwort	*Dittrichia graveolens*				
Sea Barley-grass	*Hordeum marinum*				
Barley Grass	*Hordeum sp.*				
Sharp Rush	*Juncus acutus ssp.*				

Common Name	Scientific Name	International Treaty	EPBC status	FFG status	DSE status
	acutus				
Willow-leaf Lettuce	*Lactuca saligna*				
Prickly Lettuce	*Lactuca serriola*				
Perennial Rye-grass	*Lolium perenne*				
Wimmera Rye-grass	*Lolium rigidum*				
African Boxthorn	*Lycium ferocissimum*				
Horehound	*Marrubium vulgare*				
Little Medic	*Medicago minima*				
Burr Medic	*Medicago polymorpha*				
Water Couch	*Paspalum distichum*				
Toowoomba Canary-grass	*Phalaris aquatica*				
Paradoxical Canary-grass	*Phalaris paradoxa*				
Prostrate Knotweed	*Polygonum aviculare s.l.*				
Annual Beard-grass	*Polypogon monspeliensis*				
Celery Buttercup	*Ranunculus scleratus ssp. scleratus*				
Clustered Dock	*Rumex conglomeratus*				
Curled Dock	*Rumex crispus*				
London Rocket	*Sisymbrium irio*				
Prickly Sow-thistle	*Sonchus asper*				
Rough Sow-thistle	*Sonchus asper s.l.*				
Common Sow-thistle	*Sonchus oleraceus*				
Red Sand-spurrey	*Spergularia rubra*				
Rat-tail Couch	*Sporobolus mitchellii*				
Berry Seablite	*Suaeda baccifera*				
Rat’s-tail Fescue	*Vulpia myuros*				
Fescue	*Vulpia sp.*				

Appendix F: Vegetation composition map – 22 October 2009



Appendix G: Hydrology (SWET OUTPUT)

set	Wetland Name	Lake Yando							
		Degrees	Degrees	Minutes					
set	Latitude	-36.04187	-36.00	2.5123					
set	Longitude	143.78399	143.00	47.0395					
		Metres (AHD)							
	Altitude	87.9						Runoff coefficient	
		ha	m^2	ML/ha/yr	ML/yr	Rainfall	Total (ML)	Mean	Max.
set	Local contributing catchment area	50	500000	0.2	10	362	181	0.055	0.2
		%area	Depth						
set	Initial loss to wetland bed parameters	0.25	300						
		Mean	Max						
set	Assumed average wetland bed runoff coeff	0.150	0.40						
		ML/d							
adjust	Notional artificial wetland filling inflow rate	35							
		mm/day							
adjust	Maximum artificial filling rate	60							

To operate the model
First fill in the required input data cells.
Calculation is set to Manual, so
when ready press Function9 (F9) key
It takes 20 seconds to re-calculate and plot

		Day	Month	
adjust	Irrigation year start	1	8	
		Elevation	Volume	Area
set	Wetland spill level	87.9	670913.084	787822.6
		Elevation	Tolerance for drying (m)	
adjust	Lowest wetland level	86.39	0.1	
			1 = Pan; 2 = Modelled	
choose	Factored Pan evaporation or modelled ET method?		2	

RESULT

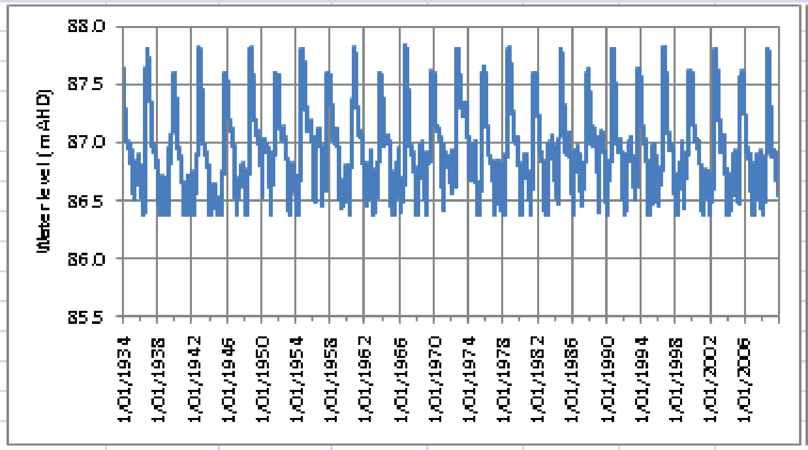
Calculated for irrigation year	Mean (ML/yr)	P95 (ML/yr)	Years with no inflow
Mean long-term annual artificial water inflows	284	904	78 in 118 years
	ML	No. Periods	Record length (years)
Average artificial water inflows for filling periods	836	40	118
Drawdowns over record (number of)	39		
Drawdowns not fully dried out (number of)	0		
Drawdowns not fully dried out (percentage)	0%		
95th percentile duration of full period (months)	4.5		
50th percentile duration of full period (months)	3.2		

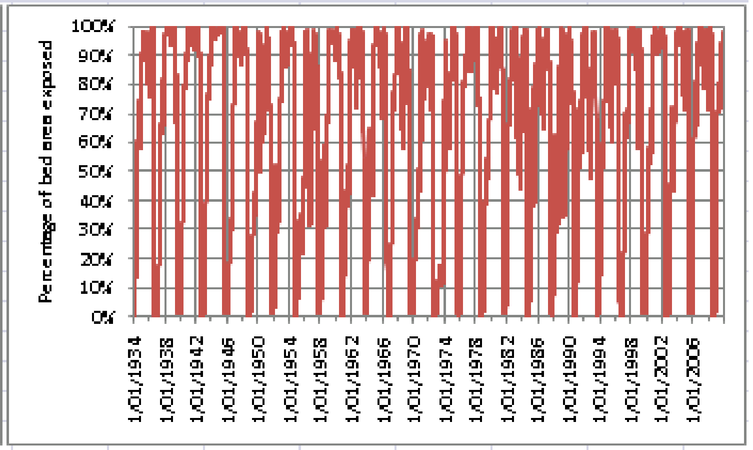
Fill cycle length (yr)	No. cycles
1	
2	
3	40
4	
5	
6	
7	
8	
9	
10	

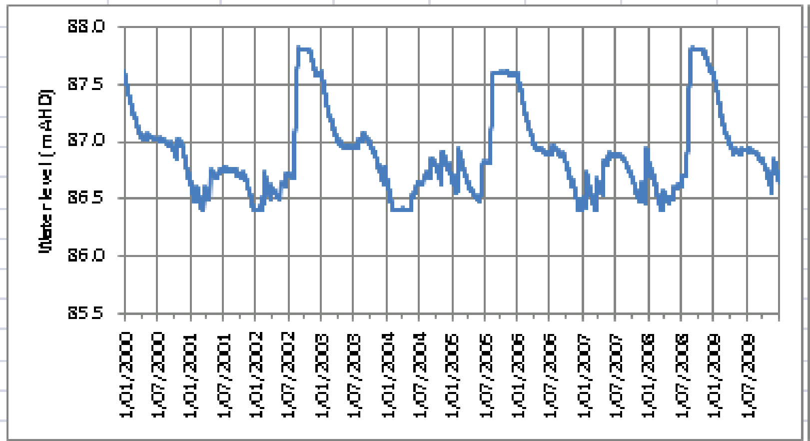
		Filling frequency		
set	Number (N) of filling events	2	events in	
set	Over management cycle length X (years)	6	years	

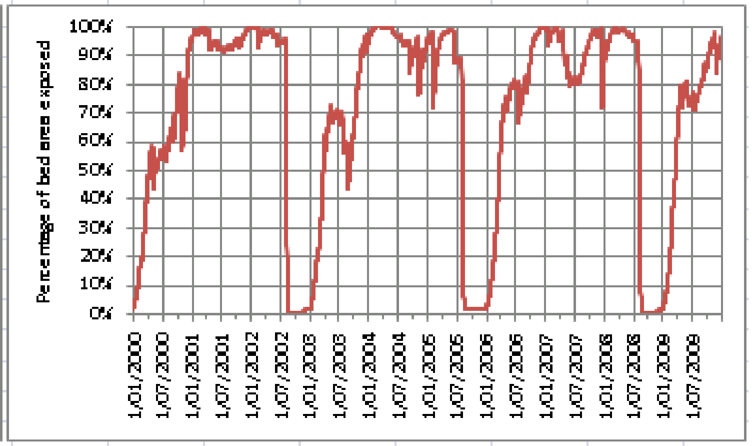
	If filling year		Filling		Staged drawdowns			Drawdown	
Year	Duration (mth)	Elevation (m)	Volume	Area	Y/N	Elevation	Durati	Volume	Area
1	5	87.59	427650	775950	N				
2									
3									
4	3	87.8	592170.2	787034.92	Y	87.59	2	427650	775950
5									
6									

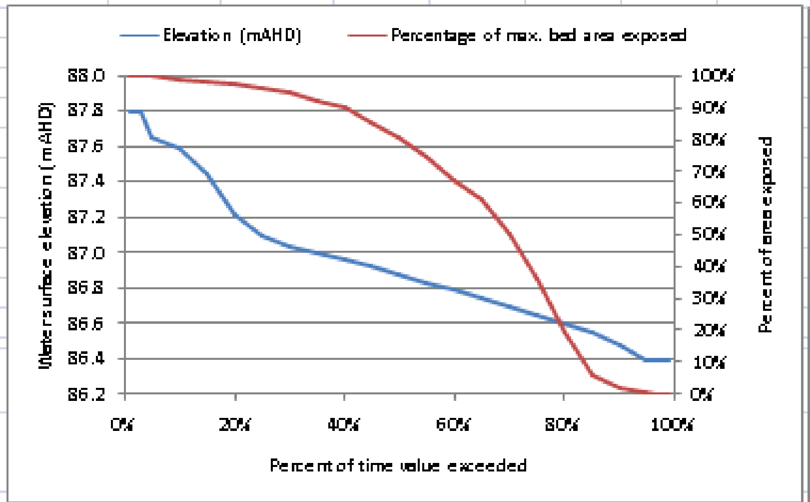
Filling		DayOfYear
Start month	8	213

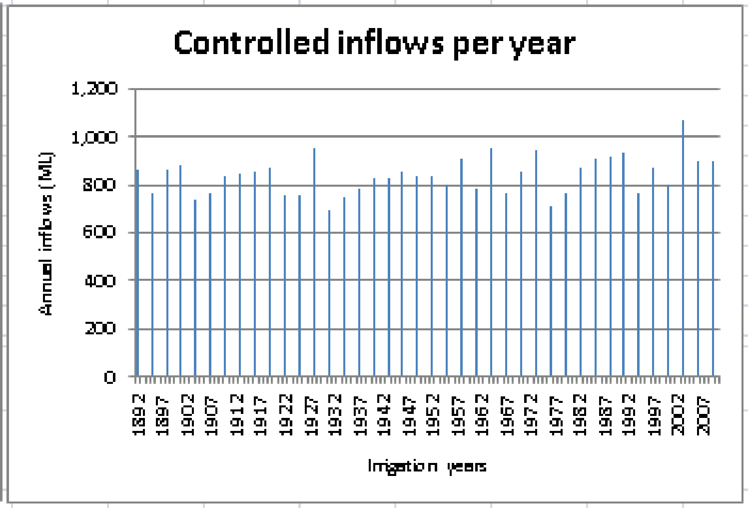












Appendix H: Preliminary leakage and seepage loss contribution calculations

Wetland	Wetland < 200 m of main supply channel (Yes/no)	Length of channel (m) <200 m	Channel width (m)	Irrigation channel	Seepage Calculation Figures					Seepage Range (min - max)	
					Channel width category	5 mm/day (ML/yr)	10 mm/day (ML/yr)	15 mm/day (ML/yr)	20 mm/day (ML/yr)	ML/yr (@ 5 mm/day)	ML/yr (@20 mm/day)
Lake Yando	No (540 m)	n/a	n/a	channel 5/2	n/a	n/a	n/a	n/a	n/a	n/a	n/a

Taken from WCMF Draft 19 March 2010 (*Table 14 Estimated volumes of seepage per year from 1000 m of channel for different channel widths and seepage rates*)

		Seepage Rate in mm/day			
Chanel width (m)	Chanel half-width (m)	5 mm/day (ML/yr)	10 mm/day (ML/yr)	15 mm/day (ML/yr)	20 mm/day (ML/yr)
10	**5**	**7**	**14**	**20**	**27**
20	**10**	**14**	**27**	**41**	**54**
40	**20**	**27**	**54**	**81**	**108**

Assumptions/Notes
Preliminary calculations were only completed for wetlands within 200 m of a main supply channel as recommended by the WCMF (19 March 2009)
Seepage rates are based on 1,000 m of channel. Where less than 1000 m is within 200 m of the wetland, seepage rates have been reduced proportionally
Seepage rates are site specific, depending on local conditions. Therefore, a range of seepage volumes for each wetland was determined using the minimum and maximum seepage rates specified in the WCMF 19 March 2010
Channel lengths, channel widths and channel distance from wetlands were measured using ArcGIS

Appendix I: Additional risks and limiting factors

The following risks are to be managed by the relevant organisations and agencies as stipulated through their current roles and as is legislated.

Risks/limiting factors	Impacts	Mitigation measures
Delivery of Water		
Inappropriate desired water regime	Loss of high environmental values and inability to achieve objectives and goal	Regular monitoring before, during and after watering events e.g. IWC, fauna (waterbirds and frogs), water quality and groundwater monitoring Adaptively manage watering regime and delivery. Re-model volumes required in light of changing climatic conditions, additional water sources and wetland phase.
Limited water availability (i.e. no environmental water allocation to provide the desired water regime)	Failure to achieve identified objectives and water management goal	Ensure sufficient information is collected for prioritisation in environmental allocation processes. Regularly review rainfall and climate data to utilise natural inflows where possible. Re-model volumes required in light of changing climatic conditions, other water sources and wetland phase.
Climatic variability	Variability in water availability (e.g. wet seasons during a planned dry phase)	Adaptive management of watering regime and delivery options as above. Re-model volumes required in light of changing climatic conditions, other water sources and wetland phase.
Poor water quality (i.e. temperature fluctuations, blackwater events, high turbidity, salinity and nutrient levels)	Reduced primary production (turbid water), limiting food resources for aquatic invertebrates and waterbirds. Excessive algal growth	Monitoring of groundwater levels, salinity and nutrient inputs in conjunction with a regular water quality monitoring program. Continue using the flushing channel and pump in accordance with operational recommendations. Adaptively manage watering regime and delivery.
Ecological Response		
Unreliable supply of food/nesting sites	Limited occurrences of waterbirds	Seasonal water delivery, regular monitoring (spring assessments) and adaptive management of watering regime to ensure suitable habitat is provided throughout breeding events.
Lag time between wetland watering and bird breeding	No successful breeding events	Seasonal water delivery, regular monitoring (spring assessments) and adaptive management of watering regime Top-ups may be required complete bird breeding events
Proliferation of pest plants and animals	Reduced habitat and resource availability Predation Limited establishment of native vegetation	Regular monitoring (e.g. IWC assessments) Active management

Appendix J: Monitoring program recommendations

It is not a requirement of NVIRP to provide long-term condition or intervention monitoring nor does this document represent a comprehensive management plan for Lake Yando. However, recommendations have been made below for variables to be monitored in order to assess the response to the provision of the desired water regime and inform its adaptive management.

It is recommended that an environmental monitoring plan is developed for the wetland, to ensure planned analysis and reporting of the impacts of the adopted watering regime (Bartley Consulting 2010).

1. Long Term condition monitoring

Long term condition monitoring is recommended in order to evaluate any changes to wetland values (particularly vegetation and groundwater) over time. It should be noted that condition monitoring is recommended to be conducted in conjunction with intervention monitoring to comprehensively evaluate any changes to Lake Yando.

Vegetation Condition and Distribution

A number of photo points and objectives for long term vegetation monitoring need to be established for Lake Yando to enable the assessment of changes in wetland condition over time. It is recommended that photos are taken from these points, facing the same direction, on a yearly basis to capture vegetation condition and distribution. It is recommended that a database be compiled in order to store details of the monitoring photos captured.

It is also recommended that the condition and distribution of vegetation communities, including exotic species, throughout Lake Yando, are assessed every five years in accordance with the statewide Index of Wetland Condition (IWC) method. The IWC not only provides useful information on the condition and distribution of vegetation but also highlights indicators of altered processes (threatening processes). It is recommended that an IWC assessment be completed for Lake Yando every 5 years. However, this may need to be undertaken sooner depending on the rate of response to watering (DSE 2005b) and should be adaptively managed.

In addition, information on vegetation communities gathered on aerial photography during this project has been digitised and is available in a GIS format to enable comparison in distribution over time (distribution mapping) (Baldwin et al. 2005).

Groundwater Monitoring

Long term monitoring of groundwater within the immediate vicinity of Lake Yando is currently conducted by DSE, DPI and local volunteers (Section 4.3). It is recommended that this monitoring continue in order to identify potential risks associated with the delivery of the recommended watering regime and for consideration in adaptive management.

It is recommended that the environmental monitoring plan to be prepared for the wetland includes a groundwater monitoring component setting out the monitoring objectives, the linkages with other monitoring programs, the monitoring approach, and the reporting and review process.

Table J1 identifies additional recommendations for improving the long-term groundwater monitoring at Lake Yando and to enhance the quality of data being collected (Bartley Consulting 2010).

Table J1: Additional groundwater monitoring recommendations (Bartley Consulting 2010)

Target	Recommendation
Long-term groundwater monitoring	A review of the groundwater-related aspects of the site, including a re-assessment of environmental risks, is undertaken at least every seven years and sooner if the watering regime is changed or regional groundwater levels rise.
	The impact of any watering regime change is reviewed and assessed in accordance with the requirements of the environmental monitoring plan, and subject to the availability of suitable data should include an appraisal of the movement of the wetting front and salt, impacts on surrounding groundwater levels and neighbouring land, and a water budget that includes estimates of accessions to groundwater.
Data quality	Installing data loggers in selected groundwater bores, to provide data before

Target	Recommendation
	watering and throughout the wetting and 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
Breadth of data collected	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 additional shallow and deep groundwater monitoring bores, at two locations at the southern end of the site
	Assessing the watertable depth and soil and salinity profile beneath the site floor

2. Intervention Monitoring

Monitoring the response of key environmental values to the provision of water is imperative in informing adaptive management of the recommended water regime. Monitoring will also assess the success of implementation, the achievement of ecological objectives and the progress towards achieving the water management goal outlined in Section 5.

It is essential that analysis of monitoring results is regularly undertaken in order to develop an understanding of changes occurring at the wetland.

Vegetation

Following the provision of water it is important that the response of vegetation is monitored. A number of previous surveys and records are available to provide baseline data in order to evaluate any response. Monthly monitoring is recommended and snapshot assessments should incorporate the components outlined in Table J2. A database of any previous flora records has been compiled for Lake Yando and should be updated following regular monitoring.

Table J2: Components of vegetation intervention monitoring

Component	Target	Method	Objective
Vegetation distribution	Submerged aquatic macrophyte vegetation, Tall Marsh habitat	• Distribution mapping • Photo points	Habitat objectives, species/community objectives
Vegetation condition		• Photo points	Habitat objectives
Species diversity	Additional species with a focus on submerged aquatic macrophyte habitat	• Species list comparison	Habitat objectives

Waterbirds

The diversity and abundance of waterbirds at Lake Yando needs to be monitored following watering for the duration of the inundation period in order to assess the success of implementation and achievement of objectives. It is essential that commentary on abundance and breeding events informs the adaptive management of the delivered water regime.

Monthly monitoring as water levels fluctuate will ensure changes in bird communities are captured (Baldwin et al. 2005). It is essential that spring surveys are conducted to adequately monitor breeding events and to inform the adaptive management of the water regime (i.e. providing top-ups to maintain water levels in order to complete breeding events). Numerous previous surveys and records are available to provide baseline data in order to evaluate the response of waterbirds to the provision of water. A database has been compiled of all recordings made at Lake Yando and should be updated regularly following monitoring. Table J3 outlines the recommended components of waterbird monitoring.

Table J3: Components of intervention monitoring of waterbirds

Component	Target	Method	Objective
Species diversity	All species including those of conservation significance	• Area searches (Baldwin et al. 2005)	Habitat objectives, 2.2
Waterbird			Habitat

Component	Target	Method	Objective
abundance			objectives, 2.2
Habitat availability	Open water (including aquatic and amphibious species), mudflats, tall marsh vegetation, Riverine Chenopod Woodland	• Undertaken in conjunction with vegetation monitoring	Habitat objectives, 2.2
Breeding populations	e.g. Black Swan,	• Nest surveys (Baldwin et al. 2005)	Habitat objectives, 2.2

Fish, amphibians and macroinvertebrates

It is recommended that the response of fish, amphibians and macroinvertebrates is monitored following watering as they provide important food sources for several waterbirds. Numerous surveys and records exist to provide baseline data to enable evaluation of the response to watering. A database has also been compiled of all recordings made at Lake Yando and should be updated regularly following monitoring. Table J4 details the components to be incorporated in monitoring fish and macroinvertebrates. Incidental observations of reptiles should also be recorded.

The results of the monitoring should also be used to inform the assessment of habitat availability for waterbirds as they provide a significant food source for a number of species.

Table J4: Components of intervention monitoring for fish and macroinvertebrates

Component	Target	Method	Objective
Species diversity	All species including those of conservation significance	• Electrofishing, bait trapping, seine and fyke netting (Baldwin et al. 2005) • Sweep netting/AusRivas • Call playback, funnel trapping, drift fences and pit traps (Baldwin et al. 2005)	Habitat objectives, 2.2, 2.3
Species abundance			

Water Quality

A monthly water quality monitoring program is required for development prior to watering the wetland. The program will assess water quality in conjunction with water level fluctuations. Table J5 identifies elements to be considered as part of the water quality monitoring program.

Table J5: Components of intervention monitoring for water quality

Component	Target	Method		Objective
Water quality	Electrical conductivity	Conductivity metre	Water quality meter	Habitat objectives, 2.1, 2.2, 2.3
	pH	pH metre		
	Turbidity	Turbidity metre		
	Dissolved oxygen	Oxygen metre		
	Nutrients	Laboratory analysis		

Appendix K: Contour and vegetation map

Lake Yando
Contours and Vegetation

Legend

Parcel

- Parcel

Lake Yando 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

- African Boxthorn
- Annual grass and Thistle
- Sharp Rush

Native

- Scattered Lignum
- Red Gum Swamp (EVC 292)
- Riverine Chenopod Woodland (EVC 103)

Infrastructure

- Channel outfall
- Outlet and Offtake points

Meters

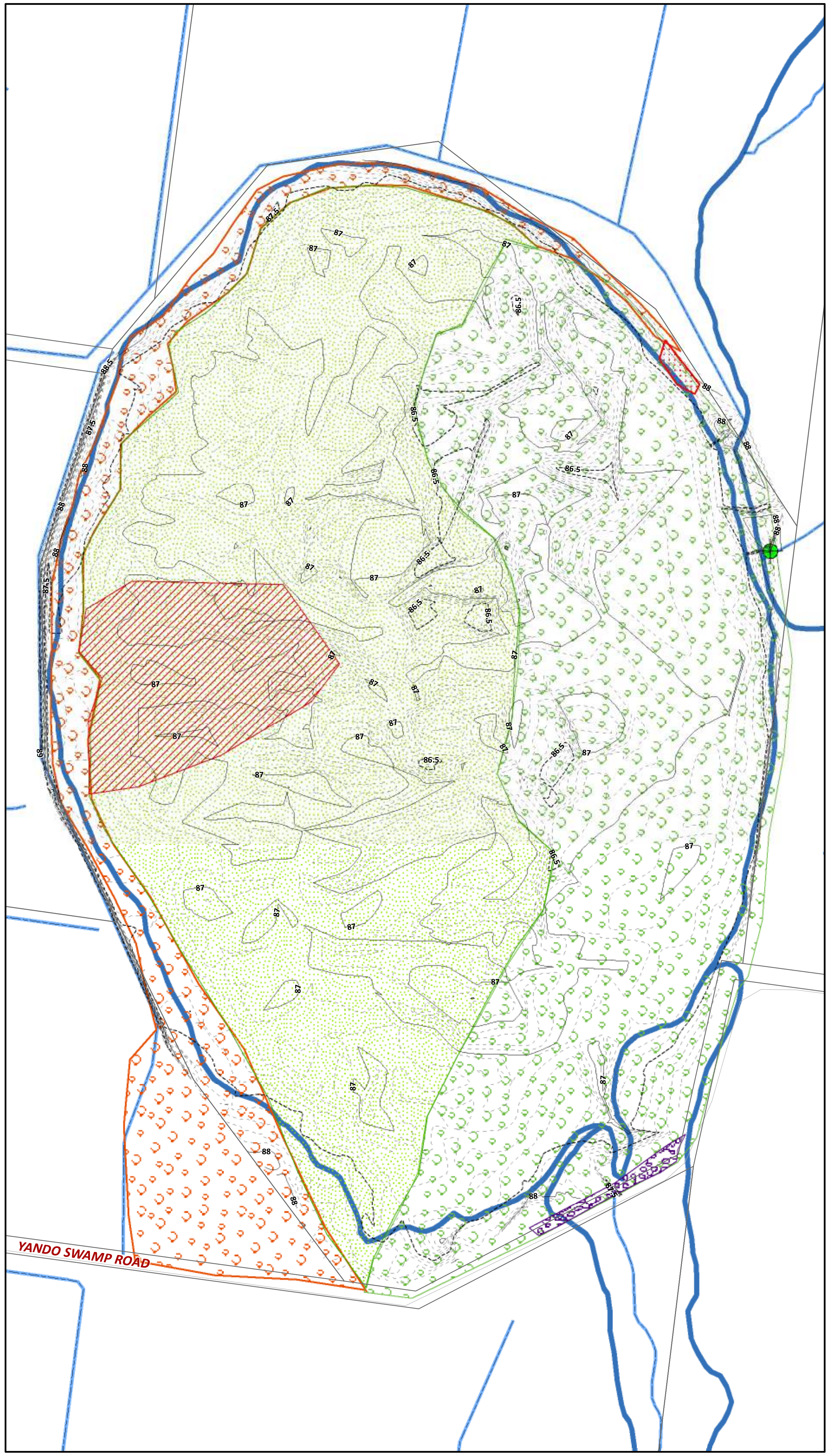
200 100 0 200

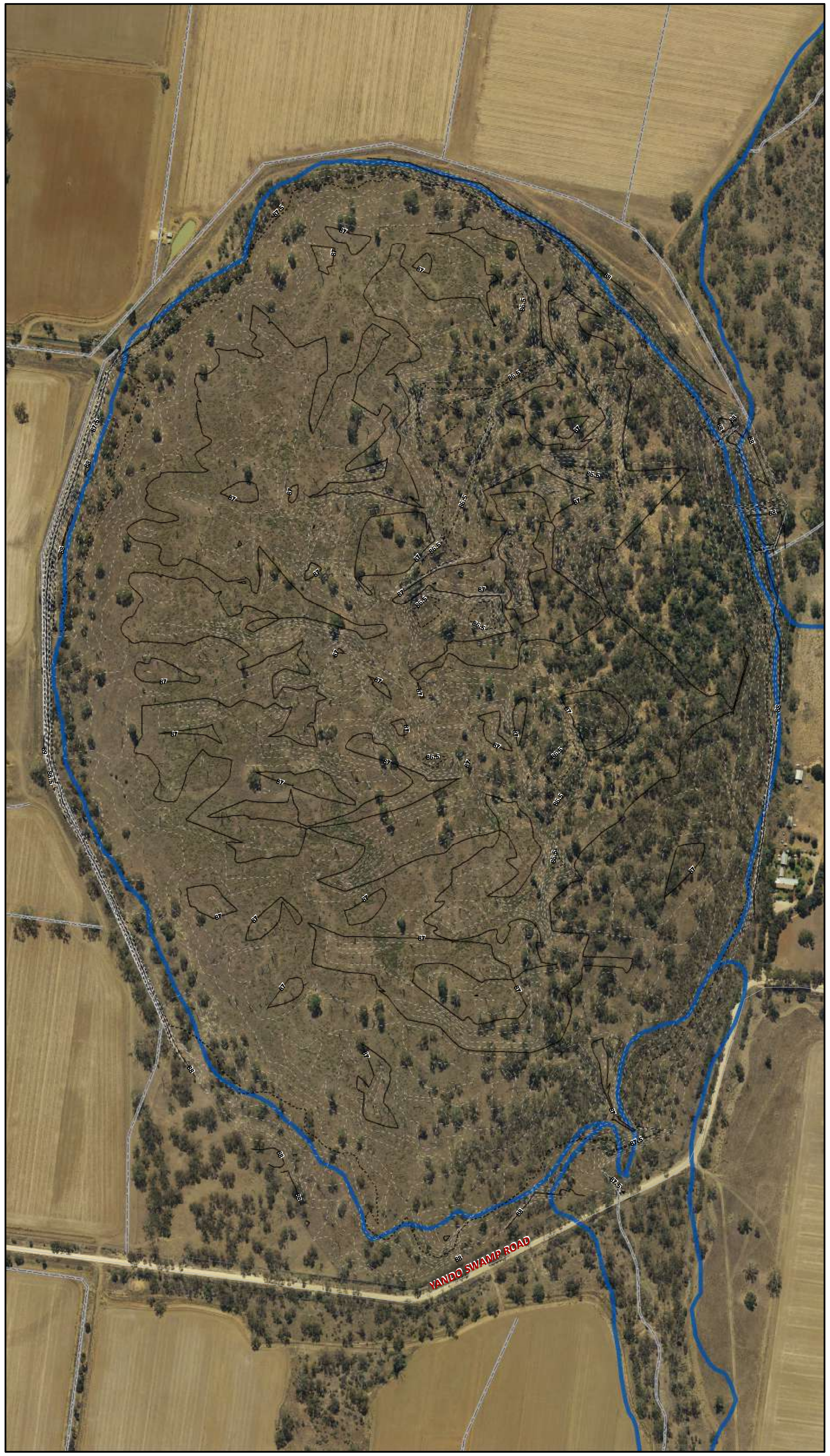
1:6,000

N W E S

Victoria The Place To Be

NORTH CENTRAL Catchment Management Authority
Connecting Rivers, Landscapes, People





NORTH CENTRAL
Catchment Management Authority
Connecting Rivers, Landscapes, People

Connecting Rivers, Landscapes, People