MCDONALDS SWAMP

ENVIRONMENTAL WATERING PLAN

NORTH CENTRAL
Catchment Management Authority
Connecting Rivers, Landscapes, People

PREPARED FOR THE
GOULBURN-MURRAY WATER CONNECTIONS PROJECT

GOULBURN-MURRAY WATER

Version 8, Final, June 2015

www.nccma.vic.gov.au

DOCUMENT HISTORY AND STATUS

Version	Date Issued	Prepared By	Reviewed By	Date Approved
Version 1	29 January 2010	Rebecca Lillie, Michelle Bills and Emer Campbell	NVIRP TAC	8 February 2010
Version 2	9 February 2010	Rebecca Lillie, Michelle Bills and Emer Campbell	ERP	10 March 2010
Version 3	7 May 2010	Rebecca Lillie, Michelle Bills and Emer Campbell	ERP	13 May 2010
Version 4	21 May 2010	Rebecca Lillie, Michelle Bills and Emer Campbell	NVIRP, ERP	28 May 2010
Version 5	28 May 2010	Rebecca Lillie, Michelle Bills and Emer Campbell	NVIRP, ERP	28 May 2010
Version 6	4 June 2010	Rebecca Lillie, Michelle Bills and Emer Campbell	NVIRP	4 June 2010
Version 7	8 July 2010	Rebecca Lillie, Michelle Bills and Emer Campbell	NVIRP, DEWHA	9 July 2010
Version 8, Draft A	January 2015	Josie Lester	ETAC, ERP	June 2015

DISTRIBUTION

Version	Date	Quantity	Issued To
Version 1	28 January 2010	Email	NVIRP TAC
Version 2	9 February 2010	Email	ERP
Version 3	7 May 2010	Email	ERP
Version 4	21 May 2010	Email	NVIRP, ERP
Version 5	28 May 2010	Email	NVIRP, ERP
Version 6	4 June 2010	Email	NVIRP, ERP
Version 7	8 July 2010	Email	NVIRP, DEWHA
Version 8 draft A	January 2015	Email	ETAC, ERP
Version 8	June 2015	Email	ERP

DOCUMENT MANAGEMENT

Printed:	4 November 2015
Last saved:	4 November 2015 02:27 PM
File name:	NCCMA-93517 – McDonalds Swamp EWP_V7
Authors:	Rebecca Lillie, Michelle Bills and Emer Campbell
Name of organisation:	North Central CMA
Name of document:	McDonalds Swamp Environmental Watering Plan
Document version:	Version 8
Document manager:	93517

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: McDonalds Swamp 2009, North Central CMA

The McDonalds Swamp 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.

appropriate for your particular purposes and therefore disclaims all liability for any error, loss or other consequence which may arise from you relying on information in this publication.

Please cite this document as: NCCMA (2015). *McDonalds Swamp Environmental Watering Plan Version 8,* Prepared for the Goulburn-Murray Water Connections Project, North Central Catchment Management Authority, Huntly, Victoria.

Management agreement

Where consistent with the obligations and responsibilities of the respective agencies, I agree to the management actions and responsibilities as described in this EWP.

NCCMA representative signature:

Print name: EMER CAMPBELL

Date: 24/10/2015

Parks Victoria representative signature:

Print name:

Date: 17/12/2015

GMW representative signature:

Print name:

Date: 22-12-2015

EXECUTIVE SUMMARY

The McDonalds Swamp Environmental Watering Plan (EWP) documents the approach to mitigating the potential impacts of the Goulburn-Murray Water Connections Project (GMW Connections Project) 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 McDonalds Swamp will be achieved for the GMW Connections Project. The main conclusions are summarised below.

Defining the environmental values of McDonalds Swamp
McDonalds Swamp is a bioregionally important wetland occupying 164 ha of a 215 ha State Wildlife Reserve. It provides a diversity of habitats which in turn attract a range of waterbird species for feeding and breeding. Of particular note, the wetland provides important open water and mudflat habitat for migratory waders in the landscape.

Part of the Murray Flora and Fauna Bulk Entitlement has frequently been used for McDonalds Swamp to maintain the wetland and provide a drought refuge for waterbirds. Since 1998, environmental water has regularly been supplied to McDonalds Swamp to compensate for declining outfalls resulting from increased irrigation efficiencies and falling regional rainfall volumes.

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

McDonalds Swamp water management goal:
Support a diversity of flora and fauna typical of a shallow freshwater marsh, in particular providing key waterbird habitat including a mix of associated grasses and sedges; Tall Marsh (EVC 821); Aquatic Sedgeland (EVC 308); Spike-sedge wetland (EVC 819), open water and mudflats.

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 McDonalds Swamp to FSL every year (one in one year). Ideally, fill in winter/spring, allow to evaporate and completely dry by February/March the following year (approximately seven month duration)[1]. Top-ups may be required to prolong the duration in order to support waterbird breeding events.

The volume of water required to provide the desired water regime for McDonalds Swamp has been assessed using a simplified version of the Savings at Wetlands from Evapotranspiration daily Time-Series (SWET) model.

The total volume required to fill McDonalds Swamp to 75.5 m AHD to provide this yearly regime is 1,345 ML. The maximum annual volume ever likely to be required (95th percentile) is 1,545 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 in waterways and wetlands resulting from GMW Connections Project. Mitigation water may be required where both:

- the waterway or wetland has received incidental irrigation water beneficial and material to high environmental values before the modernisation associated with the Connections Project, and
- where a similar contribution is assessed as being a beneficial part of a water regime which is proposed to continue to support high environmental values following the modernisation.

[1] This closely aligns with the regime described for shallow freshwater marshes which are less than 0.5 m deep and are inundated for less than 8 months of the year.

The assessment process for the requirement of mitigation water demonstrates that the **outfall water provides significant benefit to McDonalds Swamp and mitigation water is warranted.** In particular, if the volume of outfall water was to be reduced or removed, additional water would need to be secured to maintain the wetland's environmental values (specifically waterbird habitat). The baseline year incidental water contribution at the wetland (121 ML) equates to 9% of the mean annual volume of water required to provide the desired water regime (1,298 ML).

The incidental water at the origin was 121 ML in the baseline year and the annualised baseline mitigation water volume was calculated as 121 ML. The Mitigation Water Commitment for McDonalds Swamp is 100%. This will be used to calculate the interim mitigation water share of any annually calculated water savings.

As part of the 2015 review of this EWP, the estimate of mitigation water volume was amended to account for operational changes to do with the 2/3 channel. The 2/3 channel no longer services customers below the TO69 regulator and is used exclusively for water delivery to McDonalds Swamp when required. Based on this 2 km of channel delivering water once per year for 42 days, the channel losses are estimated to be 15 ML, increasing the mitigation water from 121 ML to 136 ML.

Infrastructure requirements
Currently, the automated regulator and delivery channel to McDonalds Swamp have a capacity of 50 ML/day which equates to a minimum of 17 days to fill the wetland from empty, assuming that no losses occur and operating at full capacity. In 2009 however, with an average delivery rate of 21 ML/day, believed to be constrained by the siphon passing flows under the Piccaninny/Barr Drain, it took approximately 42 days to fill the wetland. The current delivery infrastructure is considered adequate to deliver the desired water regime and no infrastructure upgrades are recommended as part of GMW Connections Project.

Adaptive management framework
An adaptive management approach (assess, design, implement, monitor, review and adjust) is incorporated into the EWP. Monitoring results are used to correct or confirm the conceptual model and management hypotheses linking the watering regime to the ecological and hydrological outcomes (in this case, watering regime to ecological and hydrological objectives).

The McDonalds Swamp 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 McDonalds Swamp.

CONTENTS PAGE

ACKNOWLEDGEMENTS

The information contained in the McDonalds Swamp Environmental Watering Plan (EWP) of July 2010 (Version 7) was 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 and Associates)
- Shelley Heron (Kellogg Brown and Root)
- Stan Archard and Dustin Chislett (Archards Irrigation)
- Mark Reid (DPI Primary Industries Research Victoria)
- Andrea Joyce, Murray Rhoda and Heath Dunstan (Department of Sustainability and Environment)
- Mark Tscharke (Parks Victoria)
- Ross Stanton (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)
- Ken Lancaster (Landholder)
- Betty Waterson and Norma Sheridan (Bird Observation and Conservation Australia)
- Graham Hall, Bridie Velik-Lord, Rebecca Horsburgh, Peter McRostie, Lyndall Rowley (North Central CMA).

The EWP was updated in January 2015 (Version 8), in consultation with:

- Emer Campbell and Bree Bisset (North Central CMA)
- Andrea Keleher and Bruce Mathers (Department of Environment, Land, Water and Planning)
- Goulburn-Murray Water Connections Project Environmental Technical Advisory Committee
- Chris Solum, Ross Plunkett, Ed Thomas and Rick Easton (Goulburn-Murray Water).

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
DEDJTR	Department of Economic Development, Jobs, Transport and Resources
DELWP	Department of Environment, Land, Water and Planning
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
GMW	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
TAC	Technical Advisory Committee

TIS	Torrumbarry Irrigation System
VEAC	Victorian Environmental Assessment Council
VROTS	Victorian Rare or Threatened Species
WCMF	Water Change Management Framework

1. Goulburn-Murray Water Connections Project

The Goulburn-Murray Water Connections Project (GMW Connections Project), formerly 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 429 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-GMW Connections Project 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, now GMW Connections 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*

GMW Connections Project has developed a Water Change Management Framework (GMW 2013) in response to this condition. The framework outlines the processes and methods for preparing Environmental Watering Plans (EWPs) to mitigate potential impacts on wetlands and waterways at risk from the implementation of the GMW Connections Project through adaptive water management (GMW 2013).

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

1.2. Decision under the Environment Protection and Biodiversity Conservation Act 1999

On the 10 May 2010, the Minister for Environment Protection, Heritage and the Arts approved the NVIRP, now GMW Connections Project, under the *Environment Protection and Biodiversity Conservation Act 1999*, subject to several conditions. The conditions that apply to the protection of wetlands and waterways include:

Condition 3: *This condition applies equally to sites identified through the Water Change Management Frameworks…as requiring the preparation of an environmental watering plan (plan). This includes Johnson Swamp. All plans must be prepared in accordance with the Water Change Management Framework and provided to the Minister for approval. No modified operations potentially impacting on a site to which a plan relates may occur until the plan has been approved by the Minister. All approved plans must be implemented.*

GMW Connections Project has developed this Environmental Watering Plan in accordance with the EPBC Act decision and the Water Change Management Framework (GMW 2013).

1.3. Water Change Management Framework

The Water Change Management Framework (GMW 2013) sets out the overarching key principles with respect to environmental management for the operation of the modified GMID. These principles include:

- GMW Connections Project will strive for efficiency in both water supply and farm watering systems.
- GMW Connections Project will design and construct the modernised GMID system to comply with environmental requirements as specified in the no-EES conditions.

- GMW Connections Project 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 GMW Connections Project 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) identified 23 wetlands and 17 waterways with significant environmental values which were potentially at risk from the GMW Connections Project, particularly by significant reductions in channel outfalls across the GMID. A wetland shortlisting report undertaken by Hydro Environmental (2009) reduced this number to 10 wetlands, which EWPs needed to be prepared. Feehan Consulting (2009) shortlisted the waterways, resulting in four waterways requiring EWPs.

EWPs have been required for two waterways and a wetland as a result of further information and scope changes.

While GMW Connections Project 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 GMW Connections Project 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 (GMW 2013).

1.4. 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 (GMW 2013). Each EWP will:

- identify environmental values of the wetland
- identify the water required to protect the environmental values
- define the environmental water regime and the sources of water
- identifying 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 land, water and catchment managers.

GMW Connections Project 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. GMW Connections Project 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 (GMW 2013).

1.5. Development process

The McDonalds Swamp EWP was initially developed in 2010 in collaboration with key stakeholders including Goulburn–Murray Water (G-MW), NVIRP (now Goulburn-Murray Water Connections Project), the Department of Sustainability and Environment (DSE; now Department of Environment, Land, Water and Planning [DELWP]), Parks Victoria and the Department of Primary Industries (DPI; now Department of Economic Development, Jobs, Transport and Resources [DEDJTR]) 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
- identifying need to provide mitigation water and, if needed, determine the quantification of mitigation water
- assessing infrastructure requirements
- developing recommendations on governance arrangements and adaptive management
- consulting and engaging stakeholders and adjacent landholders.

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

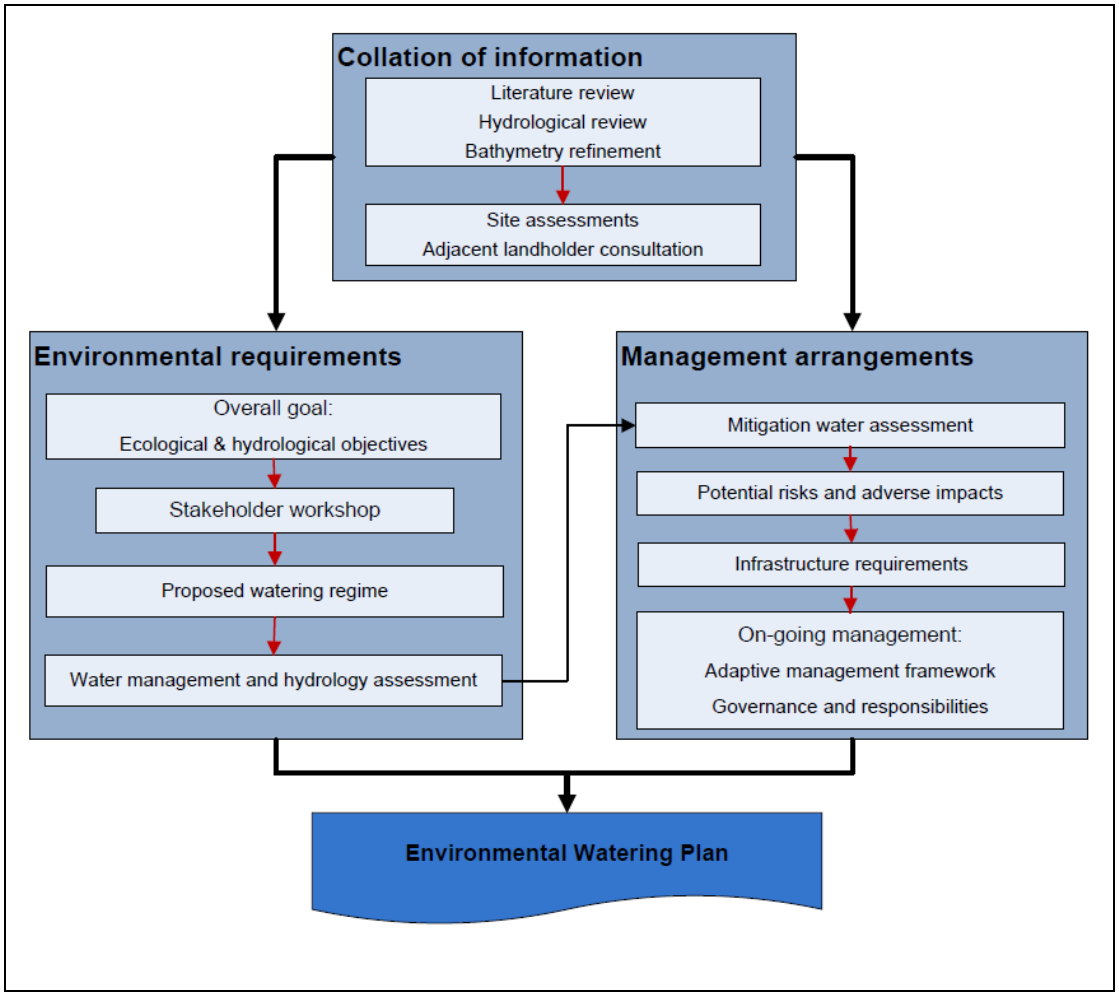


Figure 1: EWP development process

1.5.1. Consultation and engagement

To assist in collating information for the McDonalds Swamp 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, GMW, DPI (now DEDJTR), NVIRP (now GMW Connections Project) and DSE (now DELWP) (Appendix A). A content template for the EWPs was developed and approved by the TAC.

The TAC is now replaced by the GMW Connections Project ETAC and has representation from CMAs, GMW, DEWLP, DEDJTR and Parks Victoria.

A workshop was held on 17 December 2009 with key agency stakeholders and technical experts (Appendix A) in order to discuss and refine the water management goal, ecological objectives, and water requirements for McDonalds Swamp.

Consultation was also undertaken with adjoining landholders (18 January 2010) 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 GMW staff and bird observers. A summary of the information sourced from this process is provided in Appendix B.

1.5.2. 2015 Review

This review was completed in consultation with the CMAs, GMW, DEWLP, DEDJTR and Parks Victoria. GMW Connections Project prepared a report (GMW 2015) to review the ecological data for each EWP site against the stated ecological objectives. The DSE Approvals Working Group has been replaced by the Environmental Technical Advisory Committee (ETAC), comprising departmental representatives (see Appendix A for membership). This report has been revised and updated, and approved by the GMW Connections Project ETAC, and has been reviewed by the GMW Connections Project ERP.

This document was reviewed in 2015, in accordance with the requirements of the WCMF (GMW 2013). The review considered whether there was any new hydrological and ecological knowledge to be considered, changes impacting on the mitigation water assessment and changes to project and departmental names. Specific changes to Version 7 of this document are:

- Updating of site ecological information (Section 3)
- Updating of site hydrological information (Section 4)
- Recalculation of mitigation water due to infrastructure changes (Section 5)
- Addition of overabundance of *Phragmites* and *Typha* to site risks (Section 6)
- Updating water delivery arrangements due to infrastructure changes (Section 7)
- Updating of roles and responsibilities of agencies (Sections 8, 9 and 10)
- Administrative changes such as project and departmental name changes (throughout document).

1.5.3. Cessation of GMW Connections Project

The GMW Connections Project is scheduled for completion in June 2018. At this time, as per Section 9.4.4 of the WCMF, the responsibility for delivery of mitigation water will transfer to the designated environmental water manager, operating under the Victorian Environmental Water Management Framework. The entitlement itself will be held by the Victorian Environmental Water Holder. Calculation and confirmation on the LTCE conversion factor will be required from DELWP to finalise mitigation water arrangements prior to handover. This will be decided at or near the end of the GMW Connections Project.

2. McDonalds Swamp

McDonalds Swamp is situated approximately 13 km east of Kerang and 10 km west of the Murray River (Figure 2). The wetland is traversed by the Piccaninny/Barr Drain which separates it into McDonalds Swamp East and McDonalds Swamp West (Appendix C). The EWP addresses McDonalds Swamp West only, which receives G-MW channel outfall water. McDonalds Swamp is of bioregional conservation significance (NLWRA 2002, cited in NCCMA 2005) due largely to the waterbird habitat values supported by the wetland (SKM 2008).

McDonalds Swamp occupies approximately 164 ha of a 215 ha Crown land reserve[2] (Archards Irrigation 2010). It has a full supply level (FSL) of 75.50 m AHD at which height the storage capacity in McDonalds Swamp is 872 ML with a maximum depth of 80 cm (Archards Irrigation 2010).

Refer to Appendix C for the contour plan prepared for McDonalds Swamp by Archards Irrigation (2010).

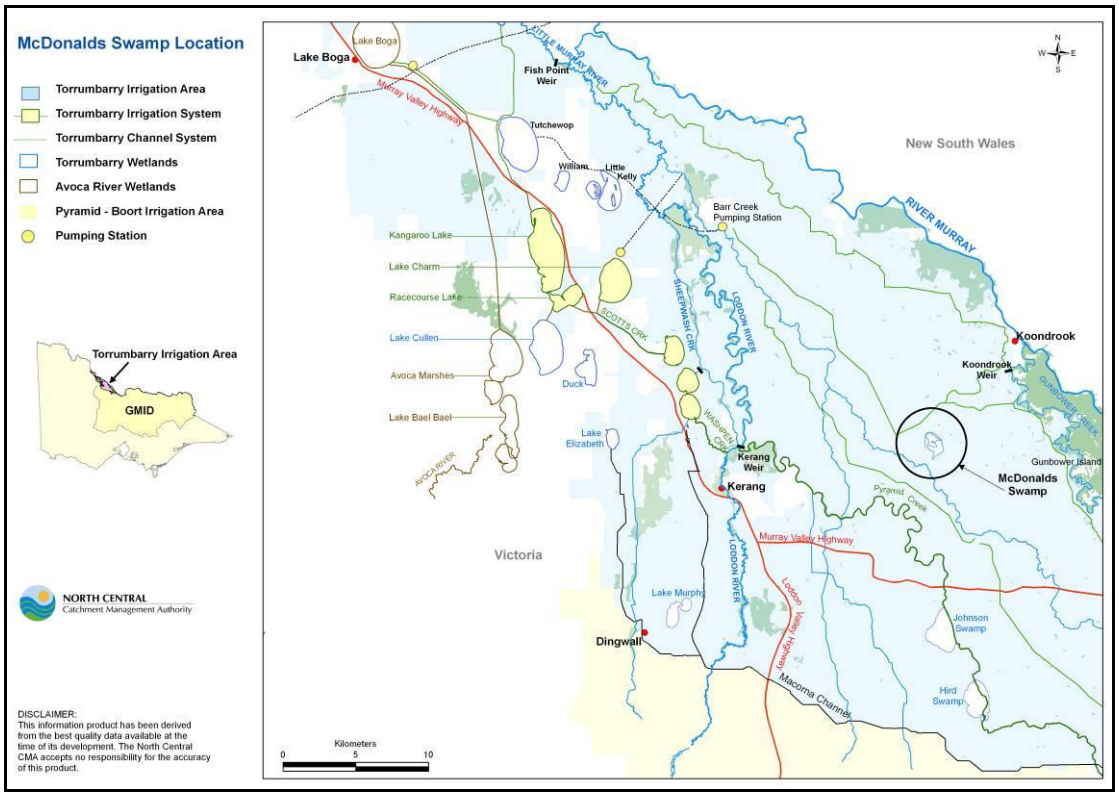


Figure 2: Location of McDonalds Swamp

2.1. Wetland context and current condition

Prior to European settlement, McDonalds Swamp was a shallow freshwater marsh[3] dominated by River Red Gums (DSE 2009a). It would naturally have received floodwaters from Piccaninny/Barr Creek when Gunbower Creek was running high (Appendix B). Naturally, flows would enter Red Gum Swamp 500 m to the northeast, then McDonalds Swamp and Barr Creek. Groundwater levels were probably 10 to 20 m below the surface, with McDonalds Swamp acting as a temporary source of groundwater recharge (SKM 2001).

The introduction of irrigation from the late 1880s[2], the establishment of the Torrumbarry Irrigation System in the 1920s, construction of levees across the floodplain and the dredging of the Piccaninny/Barr Creek in the 1960s have resulted in significant changes to the

[2] The Wetsys Database formerly reported that McDonalds Swamp occupies 366 ha. This area appears to include the public land reserves of both McDonalds Swamp and Red Gum Swamp to the north east.
[3] Shallow freshwater marshes are generally less than 0.5 m deep and are inundated for less than 8 months of the year (DCFL 1989).

hydrology of the wetland. McDonalds Swamp can no longer receive water from the Piccaninny/Barr Creek. However, end of irrigation season channel outfalls, irrigation drainage inflows and rainfall rejection flows delivered via channel 2/3 resulted in a more permanent system (SKM 2001 and Appendix B). Following development of the irrigation system, groundwater levels within the Kerang region rose dramatically to within 80 cm of the surface (SKM 2001; Bartley Consulting 2009).

The surrounding land use of the area has changed significantly in the past 100 years. Although once surrounded by dairy farms, adjacent land use now consists primarily of broadacre dryland cropping and grazing (pers. comm. Bree Bisset [NCCMA], 16 January 2015).

Stags remain as evidence of the River Red Gums that once dominated the wetland. They are thought to have died in the late 1800s as a result of prolonged inundation (>3 years) and a period of elevated salinity levels (pers. comm. Stan Archard [Archards Irrigation], 18 January 2010). Only a few regenerating River Red Gums currently exist within the wetland but these appear to be in good health (Campbell *et al*. 2009).

Following establishment of the irrigation system McDonalds Swamp received significant volumes of outfall water, rarely drying out (pers. comm. Rob O'Brien [DPI], 8 February 2010). In more recent times channel outfalls reduced dramatically and there was a requirement to utilise environmental water (discussed further in Section 4).

During the dry phase between 2006/07 and 2007/08 a large proportion of the wetland floor supported a range of common weed species including Wild Lettuce *(Lactuca* sp.) and *Brassica* sp. These annual weeds are pioneer species and may reduce over time as natives re-establish (pers. comm. Rob O'Brien [DPI] 8 February 2010).

The Swamp was inundated resulting from the provision of environmental water in autumn and spring of 2009 from the Murray Flora and Fauna Entitlement. Consequently, the wetland currently supports open water, with Tall Marsh (EVC 821), Aquatic Sedgeland (EVC 308) and Spike-sedge Wetland (EVC 819) vegetation (Section 3) with abundant dead standing (and fallen) timber.

A condition assessment undertaken in 2014 reported that McDonalds Swamp continues to display a diverse range of species and habitat for which the wetland is highly valued (Rakali Ecological Consulting 2014). The main habitat components provided by McDonalds Swamp (Campbell et al 2009) and mapped in 2014 (Rakali Ecological Consulting 2014), are summarised below:

- Open water (Plate 1) and fringing mudflat habitat. However, open water segments supported very little to no aquatic vegetation. Only floating fragments of Water-milfoil (*Myriophyllum* sp.) were observed.
- Extensive stands of dense Cumbungi (*Typha* sp.) and Common Reed (*Phragmites australis*.) exist to the south-east within the vicinity of the current channel outfall (Plate 2). In addition, Cumbungi is scattered across McDonalds Swamp with large stands also persisting towards the western boundary in association with a small drain (8/1/1).
- A range of sedges are sustained by shallow inundation and waterlogged mud to the south and west (Plate 3 from 2009 and Plate 4 from 2014). Species observed include Common Spike-sedge (*Eleocharis acuta*), Salt Club-sedge (*Bolboschoenus caldwellii)*, and Rush (*Juncus* sp.). Black Box (*Eucalyptus largiflorens*) and Tangled Lignum (*Muehlenbeckia florulenta*), which are characteristic species of Riverine Chenopod Woodland (EVC 103), exist to the south-east and a small patch of Tangled Lignum currently persists to the north.
- The wetland is fringed along the western boundary by salt-tolerant species dominated by Blackseed Glasswort (*Halosarcia pergranulata* ssp. *pergranulata*) (Plate 5 from 2009 and Plate 6 from 2014).
- The eastern verge, particularly the road and levee, is highly degraded and supports a range of exotic species including a number of moderate to high threat species. Those observed include Spear thistle (*Cirsium vulgare*), Patersons Curse (*Echium*

plantagineum), African Boxthorn (*Lycium ferocissimum*), Horehound (*Marrubium vulgare*), Sweet Briar (*Rosa rubiginosa*) and Variegated Thistle (*Silybum marianum*).

The vegetation was found to be in moderate condition, under the Index of Wetland Condition using 2014 EVC benchmarks. Ultimately, historically and in more recent years, McDonalds Swamp has provided a diversity of habitat types which in turn attracts a variety of native fauna, particularly waterbirds (Section 3).

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

Plate 1: Open water and dead standing timber (Source: MDFRC 2009)

Plate 2: Dense *Phragmites* in southeast corner (Source: MDFRC 2009)

Plate 3: Salt-club Sedge zone (Source: MDFRC 2009)

Plate 4: Salt-club Sedge zone (Source: NCCMA 2014)

Plate 5: Samphire shrubland on western margin (Source: MDFRC 2009)

Plate 6: Samphire shrubland on western margin (Source: NCCMA 2014)

2.2. Catchment setting

McDonalds Swamp is located in the Piccaninny/Barr Creek sub-catchment which occurs on the floodplains of the Loddon, Murray and Avoca Rivers (SKM 2001). It is situated within the Murray Fans bioregion. The local catchment area is low-lying and prone to flooding which has resulted in the deposition of rich, generally impermeable sediments (SKM 2001). It is likely that it flooded in moderate to high flood events in the Murray River prior to the construction of levees and drains across the floodplain (pers. comm. Graham Hall [NCCMA], 25 January 2010). Water flooded from the Murray River into Gunbower Creek and via Piccaninny Creek through Red Gum Swamp and McDonalds Swamp.

The Piccaninny/Barr Creek has an estimated local catchment area of 6,400 ha. However, the dredging of the creek disconnected the wetland from its natural flow path. A small area to the west of McDonalds Swamp (~100ha) constitutes the wetland's local catchment area and is drained by channel 8/1/1 (Appendix B).

Rainfall in the Kerang region averages 377 mm/year, with May to October being significantly wetter than November to April (Macumber 2002). Maximum average temperatures range from 31.5°C in January to 14°C in July, with minimum average temperatures falling to 4°C in July (Bureau of Meteorology 2009).

McDonalds Swamp is connected to the Torrumbarry Irrigation System via channel 2/3 (Figure 3) and has historically received significant channel outfalls, sometimes in excess of 40% of the wetland capacity in any one year (Section 4). In addition, the wetland received significant environmental water in twelve years between 1998 and 2014.

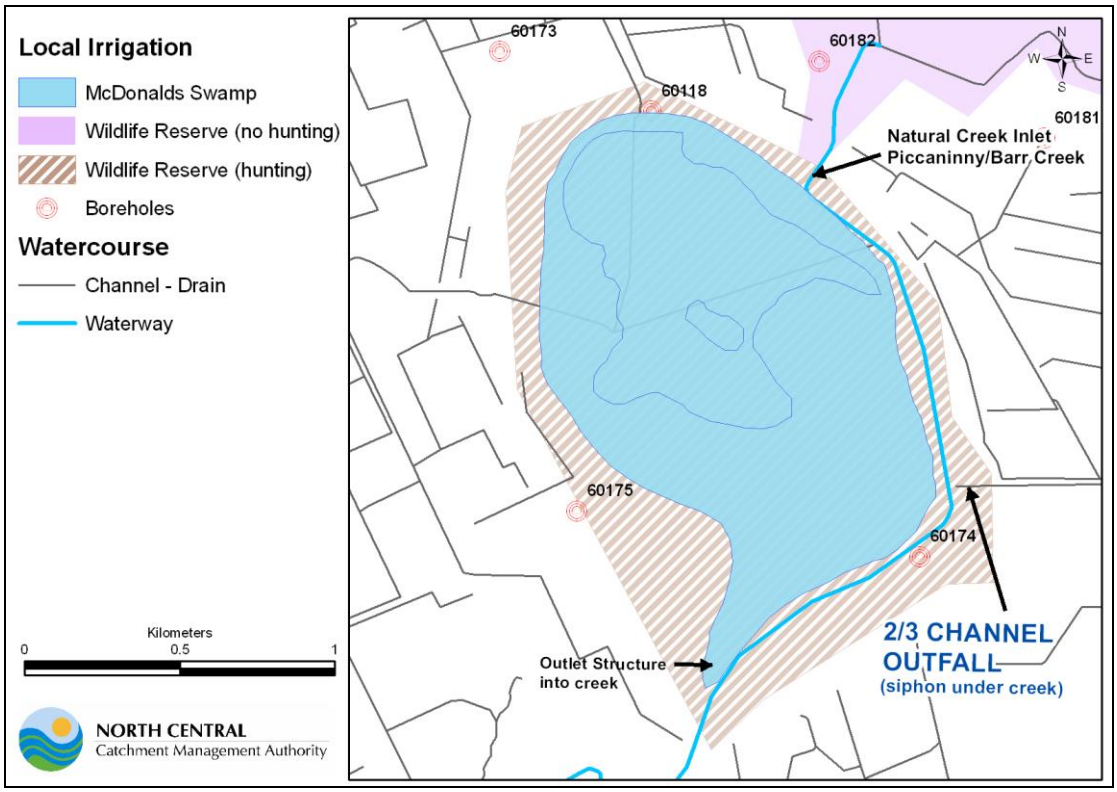


Figure 3: Inflow points at McDonalds Swamp

2.3. Land status and management

McDonalds Swamp 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 doesn't 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. McDonalds

Swamp will remain as a wildlife reserve under the "state game reserve" classification. A series of VEAC recommendations relating to the establishment of National Parks took effect on 29 June 2010. Wildlife reserves are 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; DSE 2009c).

2.4. Cultural heritage

The Kerang Lakes area is known to be one of the most archaeologically significant areas within Victoria. Numerous large cooking mounds once fringed the wetland however many were scalped off and removed during early European settlement (pers. comm. Rob O'Brien [DPI], 8 February 2010). Five mounds have been recorded in the Red Gum Swamp/McDonalds Swamp area and are registered with Aboriginal Affairs Victoria (AAV). Further information can be obtained from AAV.

2.5. Recreation

McDonalds Swamp is a valuable wetland for recreation within the Kerang Lakes area. The wetland supports:

- hunting
- bird watching (SKM 2001).

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).

McDonalds Swamp 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, McDonalds Swamp 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)[4].

McDonalds Swamp is known to support protected migratory waterbirds, some of which are also listed under the *EPBC Act* (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. McDonalds Swamp is known to support a number of species both protected[5] and listed under the *FFG Act* (Table 1 and Table 3).

[4] 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).

[5] Includes plant taxa belonging to families or genera protected by the Act (DEPI 2014).

Disturbance or collection of any of these threatened species will require a permit from the DELWP.

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 GMW Connections Project 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 GMW Connections Project 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.

Aboriginal Heritage Act 2006
All Aboriginal places, objects and human remains in Victoria are protected under the *Aboriginal Heritage Act 2006* (DPCD 2007). McDonalds Swamp is known to support sites of Aboriginal cultural significance (Section 3.2).

Other - Threatened Species Advisory Lists
Threatened species advisory lists for Victoria are maintained by the DELWP 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*. McDonalds Swamp is known to support flora and fauna species that are included on advisory lists (Table 1 and Table 3).

3. McDonalds Swamp environmental values

The primary purpose of this EWP is to assess and advise on mitigating potential impacts on high environmental values supported by McDonalds Swamp. 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; Hydro Environmental 2009; GMW 2013).

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.

3.1. Fauna

As discussed in Section 2.1, McDonalds Swamp provides a diverse array of habitat types including mudflats, open water, reeds, and dead River Red Gums which in turn attract a range of fauna species. The wetland is known to be extremely productive for waterbird use and breeding, with regular nesting reported over time (SKM 2001). For example, numerous Black Swans (*Cygnus atratus*) were observed to have bred and Grey Teal (*Anas gracilis*) were observed in their thousands following recent watering (pers. comm. Paul David [Landholder], 11 January 2010). Tree hollows situated within the wetland also provide important breeding habitat for a variety of species (including Australian Wood Duck (*Chenonetta jubata)*, Grey Teal and Chestnut Teal (*Anas castanea*).

McDonalds Swamp provides important open water and mudflat habitat for migratory waders. McDonalds Swamp, in conjunction with Johnson Swamp, Hirds Swamp and Lake Murphy, offer extensive mudflat habitat that is not offered by the permanent lakes within the Kerang region (pers. comm. Betty Waterson [BOCA], 18 January 2010). Surveys done from 2010 to 2014 show that McDonalds Swamp supports a wide range of waterbird species, with ducks, swans, large waders, small waders, coots and rails and raptors all recorded. The variety of habitats available at the site, including open water, shallow water and mudflats allows McDonalds Swamp to support a full suite of wetland birds.

More than 90 bird species have been recorded at McDonalds Swamp with records indicating that 18 are of conservation significance at an international, national and/or state level (Table 1 and Appendix E). Notably, four Brolgas were recorded in February 2014.

Table 1: Significant fauna species recorded in McDonalds Swamp

Common Name	Scientific Name	International treaty	EPBC status	FFG status	DELWP status
Australasian Shoveler	*Anas rhynchotis*				VU
Australian Painted Snipe	*Rostratula australis*	C	VU	L	CR
Brolga	*Grus rubicunda*			L	VU
Clamorous Reed Warbler	*Acrocephalus stentoreus*	B			
Common Greenshank	*Tringa nebularia*	B/C/J/R			
Eastern Great Egret	*Ardea modesta*	C/J		L	VU
Freckled Duck	*Stictonetta naevosa*			L	EN
Glossy Ibis	*Plegadis falcinellus*	C			NT
Grey-crowned Babbler	*Pomatostomus temporalis*			L	EN
Hardhead	*Aythya australis*				VU
Intermediate Egret	*Ardea intermedia*			L	EN
Marsh Sandpiper	*Tringa stagnatilis*	B/C/R			VU
Musk Duck	*Biziura lobata*				VU
Nankeen Night Heron	*Nycticorax caledonicus*				NT
Royal Spoonbill	*Platalea regia*				NT

Common Name	Scientific Name	International treaty	EPBC status	FFG status	DELWP status
Sharp-tailed Sandpiper	*Calidris acuminata*	B/C/J/R			
Whiskered Tern	*Chlidonias hybridus*				NT
White-bellied Sea-Eagle	*Haliaeetus leucogaster*	C		L	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
- DELWP listing: CR – Critically Endangered, EN – Endangered, VU – Vulnerable, NT – Near Threatened (DEPI 2013)

3.2. Flora

According to DSE's pre-1750 ecological vegetation class (EVC) mapping, prior to European settlement McDonalds Swamp was dominated by Lignum Swampy Woodland (EVC 823) and surrounded by Riverine Grassy Woodland (EVC 295) and Riverine Chenopod Woodland (EVC 103) vegetation (DSE 2009d). Lignum Swampy Woodland EVC is described as:

'Tall, mostly dense shrub layer, dominated by Tangled Lignum, in association with a Eucalypt/Acacia low woodland. The ground-layer includes a component of obligate wetland flora that is able to persist (even if dormant) over dry periods'. Characteristic Eucalypt species within this EVC are River Red Gum and Black Box (DSE 2009e).

DELWP's 2005 EVC mapping suggests that the above EVCs are still present; however Riverine Grassy Woodland (EVC 295) and Riverine Chenopod Woodland (EVC 103) are diminished in extent (DSE 2009f).

DELWP's 2005 EVC mapping was based on aerial photograph interpretation, biophysical data and selective ground truthing of sites on a project-by-project basis over a number of years (DSE 2007).

However, assessments undertaken by the Murray-Darling Freshwater Research Centre (Campbell *et al.* 2009) on 20 October 2009 identified that the wetland is currently characterised by open water with Tall Marsh (EVC 821), Aquatic Sedgeland (EVC 308) and Spike-Sedge Wetland (EVC 819) vegetation fringed by Samphire Shrubland (EVC 101) and a small patch of Riverine Chenopod Woodland (EVC 103) vegetation. These vegetation communities provide a diversity of habitat types that attract a range of fauna species. 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 shows the conservation status of the observed and mapped EVCs within McDonalds Swamp. Refer to Appendix E for a detailed map of EVCs observed in October 2009.

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

EVC No.	EVC	Bioregional Conservation Status*
821	Tall Marsh	Least Concern
308	Aquatic Sedgeland	Vulnerable
819	Spike-sedge Wetland	Vulnerable
101	Samphire Shrubland	Least Concern
103	Riverine chenopod woodland	Endangered

*Murray Fans Bioregion

Seven Victorian rare or threatened flora species (Victorian Advisory Lists) have been recorded at McDonalds Swamp (Table 3 and Appendix E). Of these, Peppercress (*Lepidium* sp) and Black Roly-poly (*Sclerolaena muricata*) have a 'poorly known' status within Victoria (SKM 2001; DSE 2005a). VEAC (2008) identified Native Peppercress as a rare or threatened flood dependent flora species. Branching Groundsel (*Senecio cunninghamii* var. *cunninghamii*) is rare within Victoria and is protected by the *FFG Act*. Similarly, Lemon

Beauty-heads (*Calocephalus citreus*) is protected by the *FFG Act* as it is part of the Asteraceae family (DEPI 2014). The most recent condition assessment (Rakali Ecological Consulting 2014) recorded three additional significant species (Table 3), Black Roly-poly, Floodplain Fireweed and Pale Plover-daisy, but failed to find the other previously recorded significant species.

Table 3: Significant flora species recorded at McDonalds Swamp

Common name	Scientific Name	EPBC status	FFG status	DELWP status
Black Roly-poly	*Sclerolaena muricata*			k
Branching Groundsel	*Senecio cunninghamii* var. *cunninghamii*		P	r
Flat Spike-sedge	*Eleocharis plana*			v
Floodplain Fireweed	*Senecio campylocarpus*			r
Lemon Beauty-heads	*Calocephalus citreus*		P	
Pale Plover-daisy	*Leiocarpa leptolepis*		L	e
Peppercress	*Lepidium sp.*			k
Spiny Lignum	*Muehlenbeckia horrida* subsp. *horrida*			r

Conservation Status:
- FFG listing: L – Listed as threatened, P – Protected (DEPI 2014)
- DELWP listing: e – endangered, 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 (DEPI 2013).

3.3. Representativeness and distinctiveness

According to DELWP's interactive mapping tool, McDonalds Swamp is classified as a deep freshwater marsh[6]. However, given it has a maximum depth of only 80 cm and holds water for less than eight months it is considered to more appropriately represent a shallow freshwater marsh.

Shallow freshwater marshes are often degraded as a result of agricultural activities, including grazing or cropping, and have subsequently decreased in extent across the landscape. The area of shallow freshwater marshes across Victoria is estimated to have decreased by approximately 60% since European settlement (DNRE 1997). Table 4 illustrates the area and proportion of shallow freshwater marshes across various defined landscapes. McDonalds Swamp, a shallow freshwater marsh, is an example of the second most depleted wetland category within Victoria.

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

	North Central region	GMID	Murray Fans
Shallow freshwater marshes (ha)	5421 (326 wetlands)	6159 (223 wetlands)	1085 (125 wetlands)
McDonalds Swamp	2.6%	2.3%	13.1%

McDonalds Swamp is distinctive because of its size. The wetland occupies 164 ha and is situated on a 215 ha crown land reserve which is considered large in comparison to other wetlands within the North Central region. Only 6% of wetlands within the region are more than 100 ha in size (NCCMA 2005).

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

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 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

McDonalds Swamp is located within the Piccaninny/Barr Creek sub-catchment which occurs on the floodplains of the Loddon, Murray and Avoca Rivers (SKM 2001). Its natural water supply would have been intermittent floods from the Piccaninny/Barr Creek when Gunbower Creek was running high (Appendix B). It would have been inundated in winter and spring, with draw-down resulting from evaporation.

The Piccaninny/Barr Creek has an estimated local catchment area of 6,400 ha (pers. comm. Graham Hall [NCCMA], 19 January 2010). Naturally, runoff would flow into Red Gum Swamp, then into McDonalds Swamp and Barr Creek.

4.2. History of water management

Construction of the Torrumbarry Irrigation System in the early 1920s, levee and flood protection measures, and the dredging of the Piccaninny/Barr Creek in the 1960s disconnected the wetland from its natural flow path. As such, a small local catchment area of ~100 ha situated to the west of the wetland provides runoff (Appendix B). In the past, end of season channel outfalls, irrigation drainage inflows and rainfall rejection flows provided by channel 2/3 resulted in an almost permanent system (SKM 2001 and Appendix B).

Surface water data collected by DELWP between 1990 and 2007 has several gaps in the monitoring record prior to 1997/1998, but does show the water regime experienced by McDonalds Swamp in those years. Surface water data has been collected only sporadically, from 2009 to 2013 (Figure 4), and resourcing constraints have limited data collection since 2013 resulting in a discontinuous data set.

Since 1998, McDonalds Swamp received significant volumes of environmental water largely to compensate for declining outfalls resulting from increased irrigation efficiencies and declining regional rainfall (Figure 5 and Table 5). The water regime shifted from permanent inundation to a seasonal regime that is alternatively wet and dry every year according to season. However, it experienced a prolonged dry period between 2006/07 and 2008/09. Following extensive flooding in the region in 2010/11, the wetland received annual watering with drying periods between water deliveries. McDonald Swamp has received water each year since 2008/09.

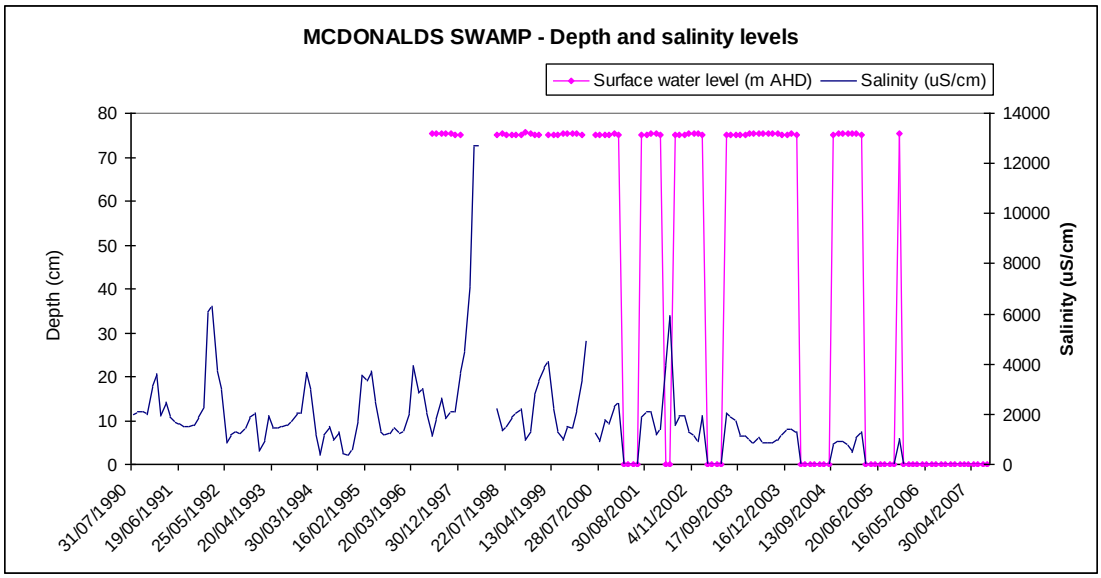


Figure 4: Surface water and salinity levels within McDonalds Swamp as recorded by DPI 1990-2007 (above) and quarterly 2009-2011 and intermittently to 2013 (below).

Table 5: McDonalds Swamp wetting/drying calendar (Source: Andrea Joyce, 2008 & NCCMA 2014)

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
w/d	w/d	w	W	d	w	w	w	W	w	w	w	w/d	d	d	w

09/10	10/11	11/12	12/13	13/14
w	w	w	W	w

Figure 5 illustrates the volumes of water received by McDonalds Swamp from outfalls and environmental water allocations (sourced from DSE) from 1998 until 2009/10. Although approximately 1,160 ML was delivered to McDonalds Swamp in 2002/03 (Figure 5 below), water levels remained below FSL at 75.50 m AHD (Figure 4 above). Recent inundation resulted from the provision of environmental water in autumn and spring of 2009 from the Murray Flora and Fauna Entitlement.

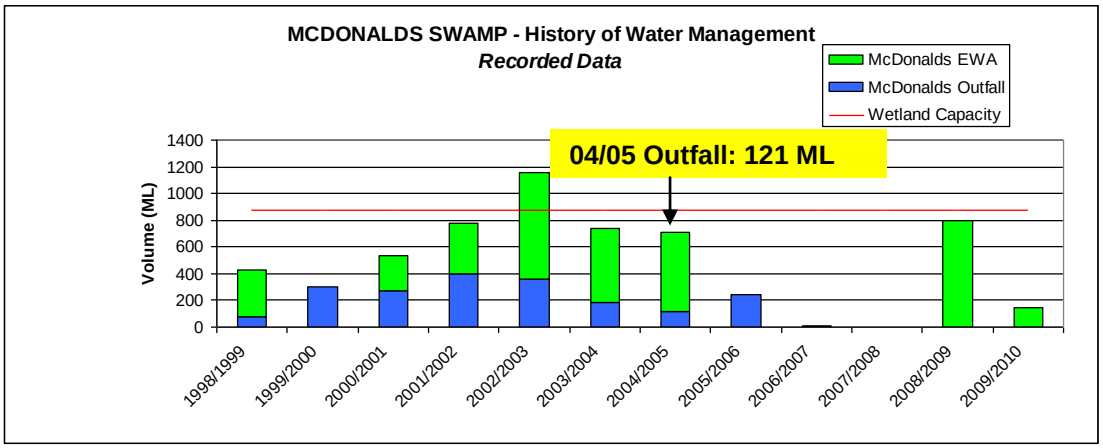


Figure 5: Recorded volumes received by McDonalds Swamp from outfalls and environmental allocations *Note outfalls recorded from 1997/1998 onwards*

4.2.1. Recorded outfalls and GMW Connections Project

Outfall data for McDonalds Swamp has been recorded by GMW since 1997/98 and the fortnightly pattern is shown for 2004/05 (Figure 5). Anecdotal evidence and records indicate that outfall volumes have decreased significantly, although not reflected in Figure 5. In the past, larger outfall volumes provided a wetter water regime which has more recently been provided by environmental water allocations (Appendix B).

The baseline water year, 2004-2005, has been selected to quantify the savings as part of water savings projects (DSE 2009g). 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 is 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 regulating structure that provides water to McDonalds Swamp recorded a total of 121 ML of outfall water in 2004-2005. The timing of the outfalls, over the irrigation period of September to May, is shown in Figure 6.

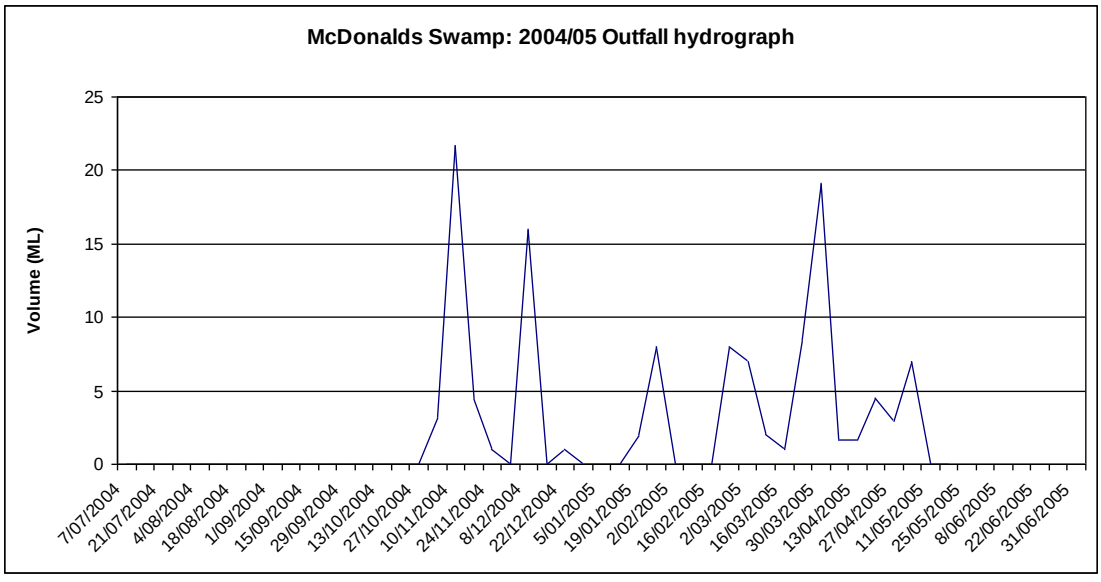


Figure 6: McDonalds Swamp outfall hydrograph

4.3. Surface water/groundwater interactions

McDonalds Swamp is situated on the Murray River Floodplain. It overlies Shepparton Formation sediments (sandy clay and clay) approximately 30 m thick, overlying Parilla Sand and Renmark Group sediments.

McDonalds Swamp would naturally have been intermittently filled and flushed by floodwaters and would have been a temporary source of groundwater recharge once the local groundwater levels receded following flood events. Groundwater levels are estimated to have been 10 to 20 m below the surface prior to European settlement (SKM 2001).

Groundwater monitoring at McDonalds Swamp is conducted by DEDJTR and local volunteers. DEDJTR collect groundwater data from regional bores in the State Observation Bore Network whilst data is collected from other bores within the vicinity by DEDJTR and volunteers. Regular monitoring of surface water and electrical conductivity commenced in 1990 and is also undertaken by DEDJTR (discussed below).

In the past, regional groundwater levels have been extremely shallow (SKM 2001); however they have been declining since the 1990s in response to a period of below average rainfall. Figure 7 illustrates groundwater behaviour from bores within the region (82754, 60178, 60179, 60180) and adjacent to McDonalds Swamp (6613, 60173 and 60174). Groundwater levels within the vicinity of the wetland have fluctuated over time. Prior to 2002, the groundwater levels were higher than the wetland bed (74.70 m AHD), nearing the surface water level. The data also illustrates seasonal fluctuations in response to recharge and evapotranspiration. However, between 2002 and 2010 groundwater levels declined dramatically to approximately 2 m below the bed. This was consistent with the behaviour of groundwater across the region, due to the prolonged drought conditions. Groundwater levels rose higher than the wetland bed again in 2011, after widespread flooding in the region. Groundwater levels have stabilised at around 74 m AHD since 2011.

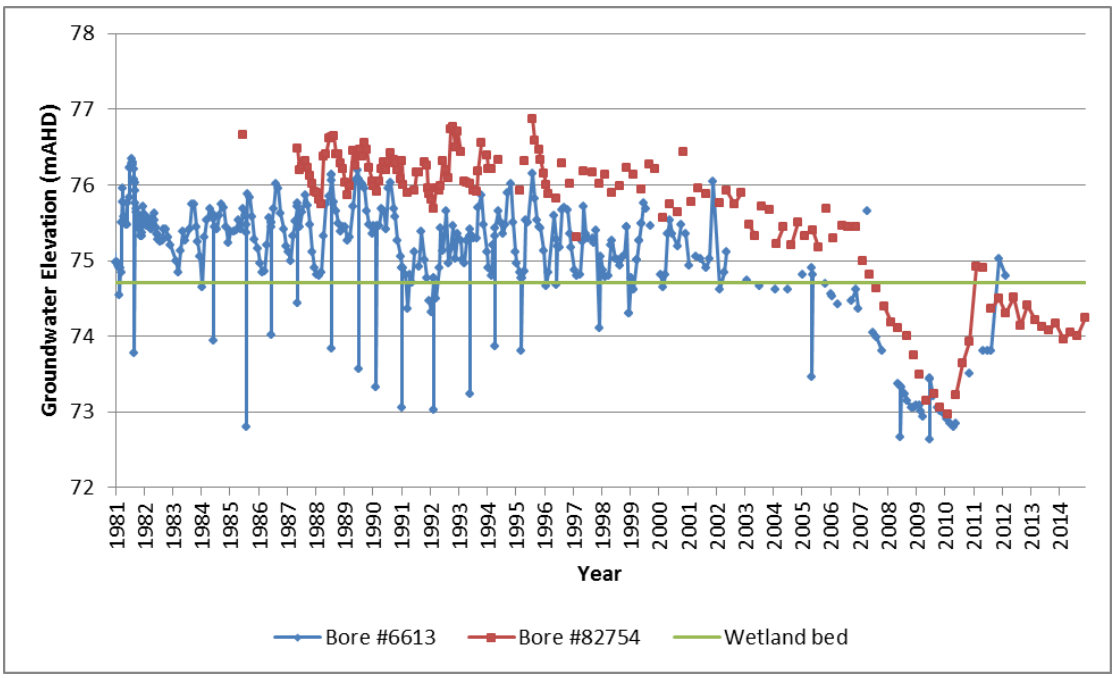


Figure 7: Groundwater levels at bores adjacent to McDonalds Swamp
(Data Source: Victorian Water Measurement Information System)

Data from bores within the vicinity of McDonalds Swamp show extremely high, fluctuating EC levels in excess of 40,000 µS/cm. Although a slight declining trend is evident, surface water EC levels are highly variable (ranging from 395 µS/cm to 12,700 µS/cm). The data suggests that as the water levels decline in McDonalds Swamp salinity increases through evapoconcentration[7] (Figure 4).

Based on 2009 groundwater levels :

[7] Concentration of salts by evaporation

- Intermittent watering of McDonalds Swamp is likely to result in localised groundwater mounding which would fluctuate in response to changing surface water levels.
- Inundation while groundwater levels are so low increases the opportunity for salts to move down the profile into the groundwater.
- There would be a small risk of saline groundwater discharge to low-lying areas on neighbouring land and drainage lines if McDonalds Swamp was permanently inundated. The risk would increase if regional groundwater levels were to rise.

If regional groundwater levels rise and McDonalds Swamp is dry, there is a risk of saline groundwater discharge into the wetland (Bartley Consulting 2009).

4.4. Surface water balance

A daily surface water balance was modelled as part of the development of the EWP in order to define the hydrological attributes of McDonalds Swamp. 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.

The model used was a simplified version of the Savings at Wetlands from Evapotranspiration daily Time-Series (SWET) (Gippel 2005a, Gippel 2005b, Gippel 2005c). This model has been approved by the Murray Darling Basin Authority for estimating the wetland surface water balance. The main components of the model are discussed in brief (following). Actual figures are provided in 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:

- **Time Series:** the daily time step is set to run from May 1891 to end of 2009.
- **Wetland capacity:** volume required to fill the wetland to the targeted supply level, i.e. McDonalds Swamp filled to a depth of 80 cm (75.50 m AHD) equates to 872 ML (Archards Irrigation 2010).
- **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 McDonalds Swamp (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 for the Kerang area (DPI and HydroEnvironmental 2007) and a local catchment area of 100 ha were used.
- **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 model was set up so as to manage water levels at a single target level (75.50 m AHD). Therefore, it is not possible to model fluctuating water levels (different target levels) overtime in order to test various management scenarios.*

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 McDonalds Swamp are presented in Section 5.3 and Appendix G.

4.5. Operational uses

Although an outlet exists at the southern end of McDonalds Swamp, the wetland is operated as a terminal system filled by rainfall, outfalls from the GMW channel 2/3 (either as operational outfall or environmental water) and surface drainage water.

A Wetland Watering and Operational Management Plan for McDonalds Swamp was developed by SKM in 2001. This document provides operational management recommendations for McDonalds Swamp with the aim of improving water quality (salinity and nutrient levels) within the wetland.

McDonalds Swamp is used as an operational outfall, although the onset of drought conditions and increased system efficiencies have considerably reduced outfall volumes received by the wetland (Section 4). There are no existing diversion licences from McDonalds Swamp (pers. comm. Ross Stanton [GMW], 21 January 2010).

4.5.1. Flood mitigation

The natural flooding of McDonalds Swamp has been restricted by the dredging of the Piccaninny/Barr Creek and the levees that resulted from associated spoil.

The wetland is not actively managed for the distribution or storage of floodwater.

4.5.2. Drainage

Although disconnected by the dredging of the Piccaninny/Barr Creek, McDonalds Swamp and Red Gum Swamp, situated to the northeast, are estimated to have a total catchment area of 6,400 ha (pers. comm. Graham Hall [NCCMA], 19 January 2010).

A small drain, channel 8/1/1, enters McDonalds Swamp to the north-west. This off-takes from channel 5/5 at Craig Road and is reported to have a capacity of 8-10 ML. The drain is blocked at present and water is re-used by the adjoining landholder (pers. comm. Ross Stanton [GMW], 25 January 2010).

As such, McDonalds Swamp receives very little runoff from its local catchment area, which is estimated to be 100 ha, particularly compared to when the surrounding land was intensively irrigated (i.e. pre-1990s) (Appendix B).

5. Management objectives

Previously, McDonalds Swamp has been managed as a deep freshwater marsh aimed at maintaining ecological and biodiversity values, mainly a diversity of native vegetation and habitat types which in turn support a variety of waterbirds. Table 6 provides information and management recommendations from the Wetland Watering and Operational Management Plan for McDonalds Swamp (SKM 2001).

Table 6: Previous management recommendations

Source	Objectives	Duration	Timing	Frequency
SKM 2001	EC range (effect of establishing aquatic vegetation)	-	Spring – EC of incoming water not to exceed 600 EC Incoming water not to exceed 1,500 EC at other times	-
SKM 2001	Fill rate (establishment of aquatic vegetation)	-	Fill rate should not exceed 2 – 3 cm / d	-
SKM 2001	Drying of wetland	Maximum dry period of 3 months in 1 year	Variable. Not to impact with bird breeding requirements	Dry at least every second year
Briggs and Thornton 1999 in SKM 2001	Waterbird breeding	5 – 10 months Mimic natural rise and fall rates	-	Dry out between floods

5.1. Water management goal

The water management goal for McDonalds Swamp 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.

McDonalds Swamp water management goal:
Support a diversity of flora and fauna typical of a shallow freshwater marsh[8], in particular providing key waterbird habitat including a mix of associated grasses and sedges (Tall Marsh (EVC 821); Aquatic Sedgeland (EVC 308); Spike-sedge wetland (EVC 819), open water and mudflats.

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 supported by McDonalds Swamp (Table 7).

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 Flora Information System (FIS) and Atlas of Victorian Wildlife (AVW) databases).

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

[8] Shallow freshwater marshes are generally less than 0.5 m deep and are inundated for less than 8 months of the year (DCFL 1989)

closely align with a specific component are provided as potential indicator species. Those species and communities of international, national and state conservation significance are given highest priority as are those that are indicative of integrated ecosystem functioning.

The objectives are 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 (Campbell, Cooling & Hogan 2005).

The ecological objectives and hydrological requirements for McDonalds Swamp were developed in conjunction with agency stakeholders and technical experts at the Wetland Workshop held on 17 December 2009. The ecological objectives and hydrological requirements were reviewed in 2015 in consultation with GMW, the CMAs, DELWP and Parks Victoria. The review found that the ecological objectives and hydrological requirements were still appropriate for McDonalds Swamp (GMW 2015).

Table 7: McDonalds Swamp proposed ecological objectives and hydrological requirements

Ecological objective	Justification	Hydrological requirement
1. Habitat objectives		
1.1 Maintain open water and mudflat habitat in sections of the wetland	Provides feeding habitat for waterbirds e.g. • Australasian Shoveler, Eastern Great Egret, Hardhead, Musk Duck, Glossy Ibis, Australian Painted Snipe	Inundate to a minimum depth of 50 cm every year for approximately seven months (one in one year[10]). Allow water levels to recede as a result of evaporation.
1.2 Maintain Tall Marsh (EVC 821) habitat including associated grasses and sedges	Provides habitat for waterbirds • Australasian Shoveler, Clamorous Reed-warbler, Intermediate Egret, Musk Duck, Whiskered Tern, Royal Spoonbill, Glossy Ibis, Australian Painted Snipe	Inundate to a depth of at least 50 cm every year (one in one year).
1.3 Maintain the Aquatic Sedgeland (EVC 308) Spike-sedge wetland (EVC 819)	Provides habitat for waterbirds, frogs and macro- and micro-invertebrates	Inundate every year (one in one year).
1.4 Restore Tangled Lignum vegetation	Lignum provides habitat for waterbirds e.g. Whiskered Tern, Freckled Duck	A small patch of large Lignum plants was observed on the northern wetland edge. Inundate to FSL every year (one in one year). Allow water levels to recede by evaporation.

[9] Timing, frequency and duration

[10] This would involve filling the wetland in winter/spring every year, allowing it to draw-down and dry in February/March before filling again the following year (as opposed to permanently inundating and maintaining water levels). Refer to Appendix K: comparison of bathymetric information and vegetation mapping.

Ecological objective	Justification	Hydrological requirement
1.5 Restore the distribution of River Red Gum • Maintain health of few existing trees • Provide opportunities for recruitment	River Red Gum trees provide hollows, fallen branches and shading for habitat, and provide a source of seed for recruitment.	Expand the distribution of River Red Gum from the few remaining trees by inundating to FSL every year (one in one year) for approximately seven months. Allow water levels to recede by evaporation.
1.6 Restore health and 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, Grey-crowned Babbler), and provide a source of seed for recruitment.	Restore health of fringing Riverine Chenopod Woodland by pushing water out into the Riverine Chenopod Woodland one in six years for two to three months.
2. Species/community objectives		
2.1 Maintain breeding opportunities for waterbirds, frogs and invertebrates The following species were observed to have bred or with breeding plumage following the watering event in 2009-10: • Masked Lapwing, Black-winged Stilts, Glossy Ibis*, Grey teal, Royal Spoonbill* *Breeding plumage observed	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 in spring and maintain inundation for seven to ten months if breeding is observed.
2.2 Maintain a viable seed and egg bank	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.	Maintain a viable seed and egg bank by enabling the establishment of aquatic and amphibious plant communities and micro and macro-invertebrate communities and maintaining suitable habitat long enough to complete life cycles. Duration variable and seasonally dependent but maintaining inundation for longer than three months every year (one in one year) should be suitable.
3. Process objectives		
3.1 Restore connectivity between river, floodplain and wetland	Connectivity facilitates dispersal and movement of plant propagules, micro and macro-invertebrates and fish, as well as nutrient and carbon cycling.	As mentioned in objective 1.6 flood the small patch of fringing Riverine Chenopod Woodland to restore some connectivity.

5.3. Desired water regime

A desired water regime has been defined for McDonalds Swamp and is presented below. This regime is based on the ecological objectives and hydrological requirements outlined in Section 5.2.

The proposed regime closely aligns with the management of McDonalds Swamp between 1998 and 2006. During this time, the wetland was filled every year and allowed to draw down and dry before filling again in winter/spring. This would facilitate a 'freshening' of the wetland by allowing salt to move down the soil profile and would encourage River Red Gum regeneration (Objective 1.5 in Table 7). A permanent system (as previously experienced)

would not facilitate River Red Gum regeneration and would potentially result in the death of existing trees and elevated salinity levels.

Figure 8 illustrates the various components of the wetland (e.g. open water, mudflats, Tall Marsh, Aquatic Sedgeland, River Red Gum) that are being targeted by the water regime.

Timing: Winter/spring[#]

[#]*Winter/spring fill is ideal, however it is recognised that water may become available for use in autumn for which an alternative extent and depth have been identified.*

Frequency of wetting: Minimum: one in two years

Optimum: Every year (one in one year)

Duration: Fill in winter/spring, allow to evaporate and completely dry by February/March of the following year. Top-ups may be required to prolong duration in order support waterbird breeding events; however, as this risks encouraging an overabundance of *Phragmites* and *Typha* populations, it is recommended that this is adaptively managed in response to monitoring conducted at McDonalds Swamp (Appendix J).

Due to elevation, fringing River Red Gum areas should be dry by late January. Areas of open water will persist longer.

Extent and depth: Ideally, fill to FSL (maximum depth 80 cm at 75.50 m AHD) in winter/spring. However, if water becomes available in autumn, fill only a proportion of the wetland (approximately 50%). This will allow less water to be used to fill the wetland in the following winter/spring. Note, however, that autumn filling also risks encouraging the overabundance of *Phragmites* and *Typha* populations if duration of dry phase is not maintained, so an adaptive management approach should again be applied.

Variability: High (target water depths will shift between inundation events depending on the previous wetting/drying cycle parameters and the status of vegetation communities determined through vegetation monitoring). Variability in extent may assist in distributing River Red Gum seed across the base of the wetland to allow for establishment of seedlings across a broader range of elevations. For example, following successful River Red Gum germination, smaller volumes of water may be applied so as not to overtop and drown establishing seedlings.

Wetland water regime:
Fill McDonalds Swamp to FSL every year (one in one year). Ideally, fill in winter/spring, allow to evaporate and completely dry by February/March the following year (approximately seven month duration)[11]. Top-ups may be required to prolong the duration in order to support waterbird breeding events.

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

[11] This closely aligns with the regime described for shallow freshwater marshes which are less than 0.5 m deep and are inundated for less than 8 months of the year

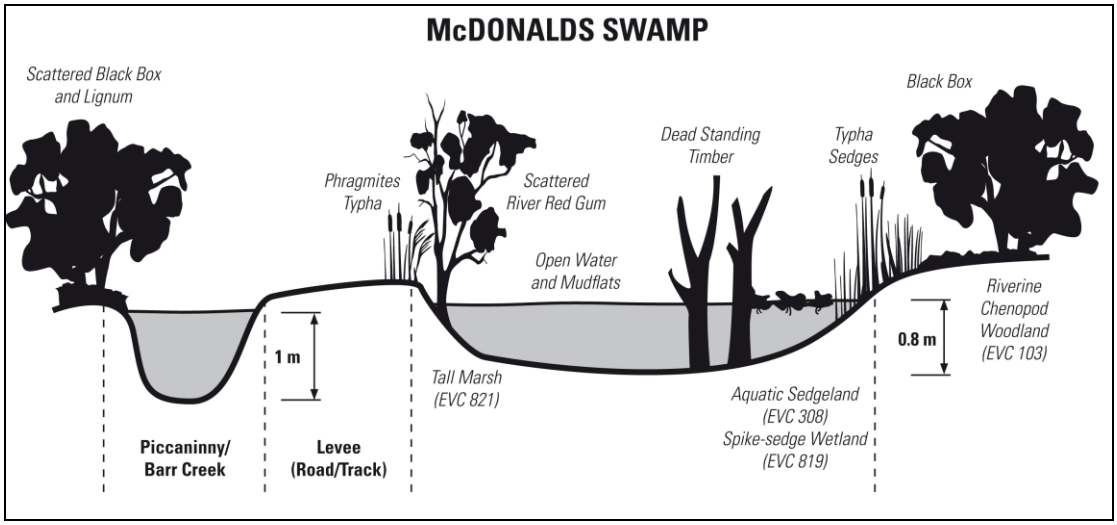


Figure 8: Schematic of wetland areas to be targeted (not to scale)

The volumes of water required to provide the desired water regime for McDonalds Swamp are presented in Table 8. These volumes reflect the results from the SWET modelling (model described in Section 4.4 and results presented in Appendix G). These calculations were prepared with the model set at filling to the target level of 75.50 m AHD. Resourcing constraints make it difficult to model a range of target levels to test various management scenarios.

Table 8: Volumes required in providing the desired water regime for McDonalds Swamp (SWET modelling output)

Result	
Mean long-term (LT) annual controlled inflow requirement	1,298 ML/year
95th percentile of mean LT annual controlled inflow requirement	1,545 ML/year
Average LT controlled inflow requirement for filling periods	1,345 ML
Record length	118
No. of periods	115
Years with no inflow	4 in 118
No. of draw downs over record	115
No. of draw downs not fully drawn down	0
% of draw downs not fully drawn down	0%
95th percentile duration of full period (months)	2.8
50th percentile duration of full period (months)	2.3

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. A mean long term annual volume of 1,298 ML to fill McDonalds Swamp to 75.50 m AHD.
- **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 (1,545 ML).
- **Average LT 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. every year). This excludes natural inflows from rainfall and local catchment runoff. Therefore, the volume required to fill McDonalds Swamp to 75.50 m AHD every year would be approximately 1,345 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 McDonalds Swamp 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 GMW Connections Project on wetlands that have become reliant on this water to support high environmental values is termed 'mitigation' water. The potential impact of GMW Connections Project considered in the McDonalds Swamp 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 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 EWPs. 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. McDonalds Swamp mitigation water

Step 1: Describe the desired water or flow regime

The desired water regime for McDonalds Swamp is filling to FSL every year. Further detail is provided in Section 5.3.

The total volume required to provide this yearly regime is 1,345 ML. The 95% percentile mean annual volume required equates to 1,545 ML/year.

Step 2: Determine the baseline year incidental water contribution[12]

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 McDonalds Swamp from leakage and

[12] 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.

seepage from nearby channels were completed based on the localised impact assessment method outlined in the Water Change Management Framework (GMW 2013). As McDonalds Swamp is more 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 GMW Connections Project actions are likely to impact the potential for leakage and seepage to McDonalds Swamp (i.e. 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 (outfall) is included in the mitigation water assessment, and the potential contributions from leakage and seepage are excluded.

In the baseline year (2004-05), the outfall volume recorded at the regulating structure was 121 ML, refer to Section 4.1. The delivery or outfall channel to McDonalds Swamp is approximately 600 m in length. An estimated 50 ML/km/year[13] 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 50 days (based on 20-25 ML/day), the loss from the open channel is estimated to be 6 ML. Therefore, approximately 115 ML (or 95%) of this outfall volume was estimated as having contributed to the wetland's water balance in 2004-05.

However, as part of the 2015 review, the estimate of the volume of mitigation water was amended to account for operational changes to the 2/3 channel. As of 2015, the 2/3 channel no longer services customers below the TO69 regulator and is used exclusively for water delivery to McDonalds Swamp when required. Thus 2 km of channel are used to deliver water once per year for 42 days, the channel losses associated with this are estimated to be 15 ML. The revised delivery time of 42 days is outlined in Section 7 of this document. These channel losses were previously attributed to the customers and will now be assigned to McDonalds Swamp.

The determination of the baseline year incidental water contribution is summarised in Table 9.

Table 9: 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 origin (irrigation system) and wetland (for baseline year) (ML)	Baseline year incidental water contribution at the wetland (Net) (ML)
Outfall #ST001206	121	6	115
Corrected channel losses	15	15	0
Totals	136	21	115

Step 3: Assess dependency on baseline incidental water contributions

The Water Change Management Framework (GMW 2013) 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 McDonalds Swamp with the results presented in Table 10.

Table 10: 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 (600 m in length) delivers outfall water to McDonalds Swamp from the automated regulator.
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	There are no diversions or impediments to outfall water being received by McDonalds Swamp. The baseline year incidental water contribution at the origin (136 ML) equates to 10% of the mean annual volume of water

[13] 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).

Criteria by which mitigation water may be assessed as not required	Link between incidental water (losses) and environmental values
evaporation before reaching the area with environmental values)	required to provide the desired water regime (1,298 ML).
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)	The wetland does not have more water than is required to support the desired state of the environmental values.
2.2 That occurs at a time that is detrimental to the environmental values	In 04/05, losses were occurring between September and May (Figure 6).
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 (irrigation outfalls) are of acceptable water quality, although the turbidity of water could be an issue for aquatic plant growth.
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)	The losses reach the wetland and support dense stands of Common Reed and Cumbungi
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)	If outfall volumes were reduced or removed, additional water would need to be secured for: • filling the wetland to FSL every year • providing top-ups to maintain water levels for breeding events
4.2 Diminish the benefits of deploying any environmental water allocations (over and above the contribution from the irrigation system)	If outfall volumes were reduced or removed, additional water would need to be secured for: • filling the wetland to FSL every year • providing top-ups to maintain water levels for breeding events

The assessment for the requirement of mitigation water demonstrates that the **incidental outfall water provides significant benefit to McDonalds Swamp and mitigation water is warranted.** In particular, if the volume of outfall water was to be reduced or removed, additional water would need to be secured to maintain the wetland's environmental values (specifically waterbird habitat). At McDonalds Swamp, mitigation water is required annually to maintain the environmental values it supports.

Step 4: Calculate the annualised baseline mitigation water volume (BMW)

The BMW volume is expressed as the baseline incidental water contributions divided by the number of years in the cycle of the desired water regime.

As there are currently no other more efficient infrastructure options for delivering mitigation water, the BMW is calculated at Outfall #ST001206 (gross).

Gross BMW

$$= \frac{\text{Baseline year incidental water contribution at origin}_{(Gross)} \text{ (Step 2)}}{\text{The inherent cycle (years) of the desired water regime (Step 1)}}$$

= 136 ML / 1 (annually)

= 136 ML

Step 5: Calculate the mitigation water commitment (MWC)

The MWC expresses the BMW (Step 4) as a percentage of the baseline incidental water contribution. It is used to calculate the share of annual water savings. These are calculated each year in accordance with the Water Savings Protocol and the associated Technical Manual (DSE 2009g) and will become available in any following year.

MWC (%)

$$= \frac{\text{Gross BMW}_{\text{(McDonalds Swamp 2004/05)}} \text{ (Step 4)}}{\text{Baseline incidental water contributions at origin}_{\text{(Gross)}} \text{ (Step 2)}}$$

$$= (136/136) \times 100$$

$$= 100\%$$

The overall MWC for McDonalds Swamp is 100%.

Step 6: Calculate the LTCE mitigation water volume

The LTCE mitigation water volume is used to account for mitigation water when reporting against the net savings target. This volume is calculated by multiplying the mitigation water commitment (Step 5) by the baseline mitigation water volume (Step 4) and the LTCE conversion factor.

Please note: calculation and confirmation on the LTCE conversion factor is required from DELWP. This will be decided at or near the end of GMW Connections Project.

5.5. Other water sources

The calculated mitigation water represents 9% of the mean annual volume of water required to provide desired water regime (1,298 ML). GMW Connections Project 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 high environmental values. As such, it is important that the environmental water holder secures additional sources of water to provide the desired water regime for McDonalds Swamp. The most likely additional sources of water will be existing and future environmental entitlements.

Discussion of potential sources of water to provide the desired water regime to McDonalds Swamp 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 used 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 GMW Connections Project 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, Stage 2 of GMW Connections Project will generate up to 200 GL of water savings, 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 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 DoE, will manage the Commonwealth's environmental water.

The *Water Act 2007 (Aust)* 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 wetlands) are considered priority environmental assets for use of the commonwealth environmental water (DEWHA 2008). Whilst McDonalds Swamp is not a wetland of international importance, it is a refuge for species listed under other International conventions. Australian Painted Snipe *(Rostratula australis)* is also listed as endangered under the *EPBC Act*. 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 water regime of which mitigation water represents 9% of the mean annual volume required (1,298 ML). Awareness of the potential risks and impacts will influence future intervention and long-term condition monitoring undertaken at McDonalds Swamp, will inform the adaptive management of the water regime and the provision of mitigation water (Section 8).

Table 11 outlines the risks, limiting factors and potential impacts associated with the provision of mitigation water as a component of the desired water regime that need to be considered by GMW Connections Project and 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 McDonalds Swamp. 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 11: Potential risks, impacts and mitigation measures associated with provision of mitigation water at McDonalds Swamp

Risks/limiting factors	Impacts	Mitigation measures
Additional sources of water are available in times other than preferred winter/spring (e.g. autumn)	Failure to achieve identified objectives and water management goal	Adaptive management of water regime and delivery of mitigation water to assist the achievement of desired goal e.g. fill a portion of the wetland to minimise the water required to fill the following winter/spring. Monitor the potential to trigger breeding events and the requirement to maintain water levels (Section 8 and Appendix J).
Extended inundation periods (e.g. for completion of waterbird breeding) may lead to overabundance of *Phragmites* and *Typha* populations	Encroaches on the other habitat types.	Allow a drying phase to manage the *Phragmites* and *Typha* populations. Avoid having long wet period often, particularly in back-to-back years. Wetland should be dry (no surface water) for 5 months and bone-dry (cracking soils) for 3-4 months. When inundation has been extended, follow with a year in which surface water present for < 6 months (as determined by monitoring of the *Phragmites* and *Typha* populations).

7. Water delivery arrangements

McDonalds Swamp receives outfalls from channel 2/3 via an automated regulating structure and delivery channel (~600 m) that enters the wetland to the east (Figure 9). A 900 mm siphon passes water beneath the Piccaninny/Barr drain that runs along the eastern side of McDonalds Swamp. The inlet capacity is reported to be 50 ML/day however the siphon has a capacity of 30 ML/day (pers. comm. Ross Stanton [GMW], 18 May 2010) (SKM 2001).

At a flow rate of 50 ML/day it would take approximately 17 days to fill to FSL from empty (not accounting for losses and operating at full capacity). However, it took 42 days to fill McDonalds Swamp at an average flow rate of 21 ML/day in 2009; and this is believed to be normal. A maximum of 38 ML was delivered in one day (pers. comm. Bridie Velik-Lord [NCCMA], 23 December 2009).

An outlet structure exists in the southern corner of McDonalds Swamp. The outlet drains water into the Piccaninny/Barr Drain where it flows into Barr Creek and then into the Loddon River.

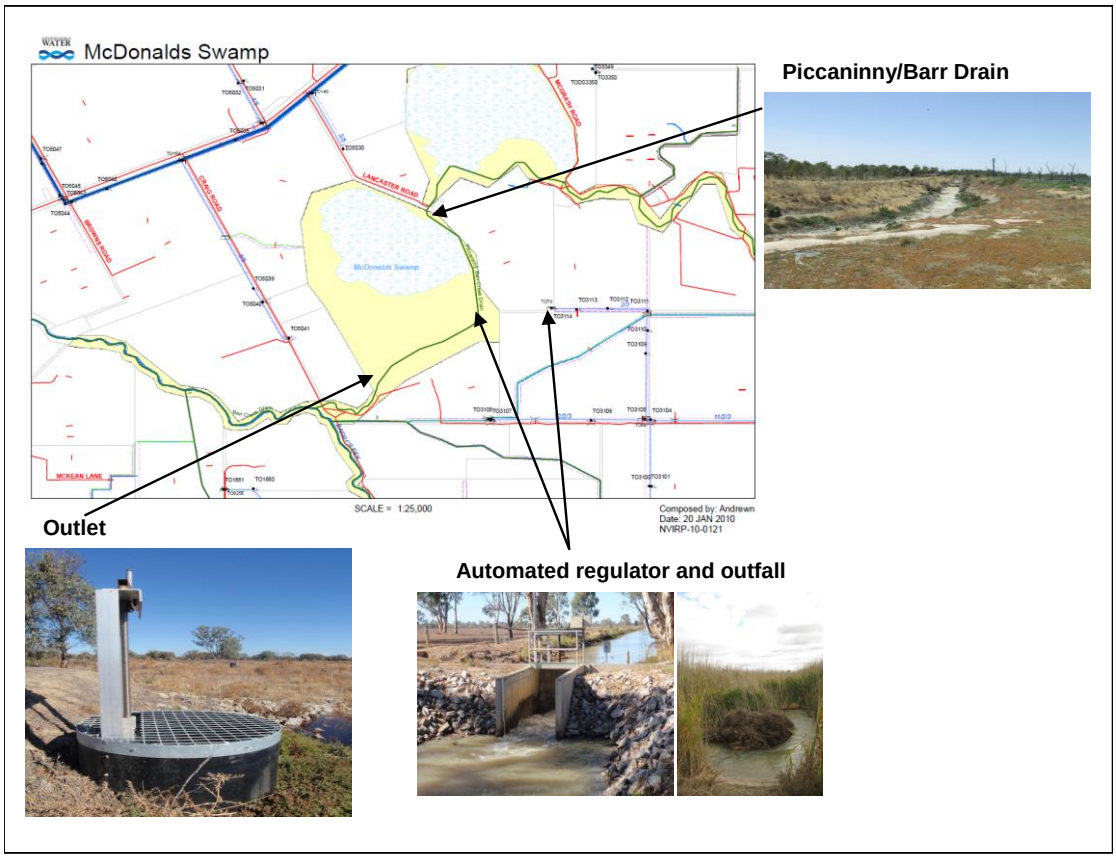


Figure 9: McDonalds Swamp Infrastructure

7.1. GMW Connections Project works program – Channel 2/3

The Stage 1 GMW Connections Project 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 Torrumbarry No. 5 channel is the backbone within the vicinity of McDonalds Swamp, situated to the north. The GMW Connections Project had considered rationalising approximately 9 km of channel 2/3 and providing a new supply point to McDonalds Swamp as part of the Connections Program. However, this section of channel is now being retained. As no customers will be serviced from below the TO69 regulator, the remaining 2 km of channel below this point will be used exclusively to supply McDonalds Swamp with environmental

water. Channel losses which were previously attributed to the customers are, therefore, now attributed to McDonalds Swamp, resulting in the 15ML increase in mitigation water.

7.2. Infrastructure requirements

The automated regulator and delivery channel to McDonalds Swamp have a capacity of 50 ML/day which equates to a minimum of 17 days to fill the wetland from empty assuming that no losses occur and operating at full capacity. Recently, however, an average delivery rate of 21 ML/day, believed to be constrained by the siphon and available channel capacity, resulted in a 44 day filling period. No upgrades to existing infrastructure are recommended as part of GMW Connections Project.

8. Adaptive management framework

A key GMW Connections Project principle is that an adaptive management approach is adopted to ensure an appropriate response to changing conditions (Section 9.4, GMW 2013).

Adaptive management is a continuous management cycle of assessment and design, implementation, monitoring, review and adjustment. Table 12 shows how the adaptive management approach will be applied in the context of this EWP.

Table 12: Adaptive management framework

Adaptive management phase	Application to this EWP (Responsible agency)	When (Sections 15 and 19, GMW 2013)
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. (GMW Connections Project)	2010
Implementation	Implementation is the active management of environmental water, of which mitigation water may form a portion, consistent with this EWP. (North Central CMA)	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 mitigation water contribution to achieving the water management goal by monitoring individual ecological objectives. (North Central CMA).	Annual
Review	Review is evaluating actual results against objectives and identifying any improvement opportunities which may be needed. (GMW Connections Project, until responsibilities transferred to other agencies)	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. (GMW Connections Project, until responsibilities transferred to other agencies, adjustment is limited to the extent that the new information relates to the impact of the GMW Connections Project at the time of the impact occurred, and only insofar as the new information could change the mitigation outcomes)	2015, 2020, 2025, etc

8.1. Monitoring and reporting

It is assumed that if mitigation water is supplied in accordance with the desired water regime proposed within the EWP then environmental values potentially impacted by GMW Connections Project will be maintained. GMW Connections Project will report, annually, on the contribution, or provision, of “GMW Connections Project Mitigation Water” towards achieving the water regime (Section 18, GMW 2013). This will be done through liaison with other agencies in relation to monitoring and then reporting whether:

- Mitigation water was available for delivery to the wetland or waterway

- A decision was made that water was required for the wetland or waterway for that year
- Mitigation water was delivered to the wetland or waterway in accordance with the desired water regime proposed within the EWP (i.e. quantity, timing, duration, frequency)
- The ecological objectives were achieved or are being achieved

It is expected the CMA will monitor environmental water delivery (i.e. quantity, timing, duration and frequency). GMW Connections Project 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.

8.2. Review

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

As per the requirements of the WCMF, it is expected this EWP will be reviewed in 2015, 2020 and every five years thereafter, or at any time, if requested by the Victorian Minister for Water or Commonwealth Minister for the Environment (Sections 15 and 19, GMW 2013). The GMW Connections Project is responsible for reviews until such time as responsibility is transferred.

8.3. Adjustment

Adjustments may be made to:

- management hypotheses and, perhaps, to ecological objectives
- operational management, if required by changes to the management hypotheses
- 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 13 (GMW 2013). The table outlines the roles and responsibilities before and during the implementation of GMW Connections Project in the modified GMID.

Table 13: Roles and responsibilities

Agency	Assess and develop management and mitigation measures	Deliver and review management and mitigation measures during GMW Connections Project implementation
GMW Connections Project (until such time as responsibility is transferred)	• identify and account for water savings, subject to audit by DELWP 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 Environmental 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 deliver management and mitigation measures. • Arrange for the provision of delivery and measurement infrastructure including capacity and operational flexibility for mitigation water
Catchment Management Authority	• Identify and inform GMW Connections Project of opportunities for best practice. • Inform GMW Connections Project of its infrastructure requirements to deliver environmental water.	• 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.

Agency	Assess and develop management and mitigation measures	Deliver and review management and mitigation measures during GMW Connections Project implementation
	• Participate in the Environmental 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 GMW Connections Project.	• Operate, maintain and replace, as agreed, the infrastructure required for delivery of mitigation water, where the infrastructure is not part of the GMW 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 GMW Connections Project. • Manage and report on other relevant catchment management and mitigation measures required due to the implementation of GMW Connections Project.
Land Manager (Public and private as relevant)	• Identify and inform GMW Connections Project of opportunities for best practice. • Participate in the Environmental 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 GMW Connections Project.	• 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 GMW 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 GMW Connections Project.
System Operator	• Identify and inform GMW Connections Project of opportunities for best practice. • Participate in the Environmental Technical Advisory Committee. • Agree to implement relevant components of Environmental Watering Plans.	• 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 GMW 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 the WCMF. • Where the infrastructure assets are due for renewal or refurbishment,

Agency	Assess and develop management and mitigation measures	Deliver and review management and mitigation measures during GMW Connections Project implementation
		the water corporation will undertake the upgrade to the best environmental practice, including any requirements to better provide Environmental Water Reserve, and to remain consistent with the current WCMF. • 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.
DELWP	• Identify and inform GMW Connections Project of opportunities for best practice. • Participate in the Environmental Technical Advisory Committee. • Arrange funding to enable environmental water manager, catchment manager and land manager to deliver agreed measures.	• Participate in the periodic review of the Water Change Management Framework and relevant EWPs.
Environmental Water Holder		• 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. • 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 by amendment to the River Murray and Goulburn System Bulk Entitlements held by GMW. This arrangement is legally binding and reflects the commitments of the GMW Connections Project to provide water to mitigate potential impacts to high value environmental assets. The arrangements require GMW 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 EWP.

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.

Delivery of environmental water to McDonalds Swamp 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 10. This has been developed to describe the decision-making process required to coordinate implementation of the desired water regime for McDonalds Swamp. The various government bodies and their roles will change over time. 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.

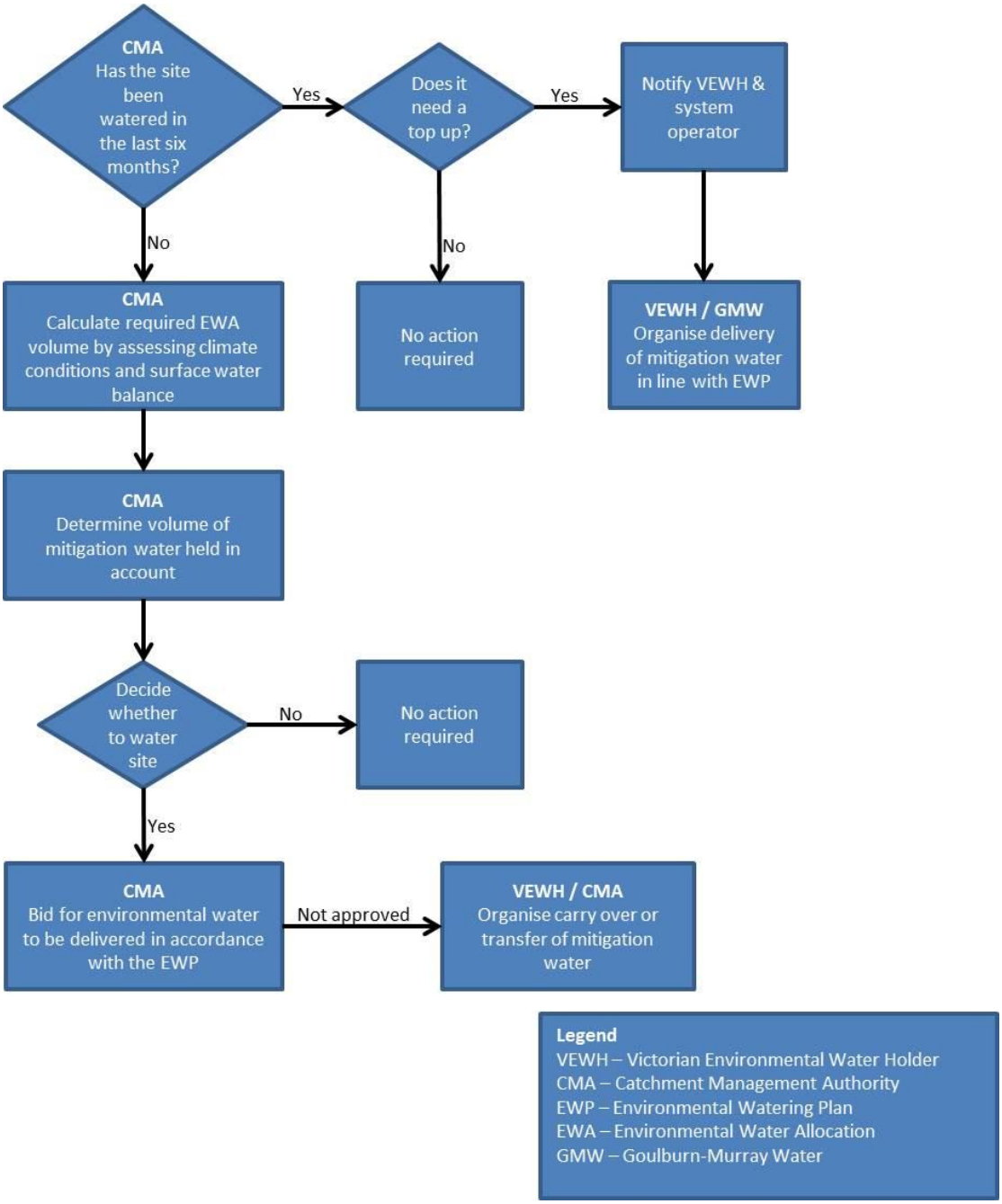


Figure 10: Operational management framework

10. Knowledge gaps

The McDonalds Swamp 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. McDonalds Swamp

- Continued monitoring and evaluation of groundwater and surface water data is recommended to ensure no detrimental impacts from implementation of the water regime.
- The relationships between hydrology and ecological response in wetlands are complex. Therefore, it will be important that monitoring and adaptive management is undertaken to enable decisions to be made based on the best available information (Appendix J).
    - Monitoring the composition and distribution of vegetation communities within the wetland will be essential to adaptively managing the desired water regime (Ecological objectives: 1.1, 1.2, 1.3, 1.4, 1.5, 1.6, 3.1).
    - In addition, continued waterbird monitoring, particularly in spring, is critical for the implementation and adaptive management of the desired water regime. Top-ups may be required to maintain water levels in order to complete waterbird breeding events (Ecological objectives: 2.1, 2.2, 3.1).
    - It is recommended that some basic photographic monitoring points are established in conjunction with aerial photography as an important component of vegetation monitoring (Ecological objectives: 1.1, 1.2, 1.3, 1.4, 1.5, 1.6).

10.2. Roles and responsibilities

North Central CMA in its capacity as environmental water manager is responsible, where funding and resourcing allow, for addressing the knowledge gaps listed under Section 10.1.

11. References

Archards Irrigation (2010). *McDonalds Swamp Contour Plan and Capacity Table.* Prepared for the North Central Catchment Management Authority. Archards Irrigation, Cohuna, Victoria

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 (2009) *Hydrogeological Overview – McDonalds Swamp.* Prepared for the North Central Catchment Management Authority by Bartley Consulting, Heidelberg, Victoria

Bureau of Meteorology (2009). *Climate Statistics for Australian Locations*. Bureau of Meteorology, Available at: http://www.bom.gov.au/climate/averages/tables/ca_vic_names.shtml, Accessed: November 2009

Boulton, A., and Brock, M. (1999). *Australian Freshwater Ecology: Processes and Management*, Gleneagles Publishing, Adelaide.

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.

DEPI (2013). *Advisory List of Threatened Vertebrate Fauna in Victoria,* The Department of Environment and Primary Industries, Melbourne.

DEPI (2014). *Flora and Fauna Guarantee Act 1988 Protected Flora List* May 2014, The Department of Environment and Primary Industries, Melbourne.

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*. Prepared by SKM, CRC for Freshwater Ecology and Lloyd Environmental Consultants for DNRE, Melbourne.

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

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

DSE (2009b). Data Source: 'WETLAND_1994', © The State of Victoria, Department of Sustainability and Environment. The contribution of the Royal Botanical Gardens Melbourne to the data is acknowledged. Accessed: January 2009.

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

DSE (2009d). 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 (2009e). *EVC Benchmark for the Index of Wetland Condition EVC 823: Lignum Swampy Woodland*, Department of Sustainability and Environment, Melbourne.

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

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

DSE (2008) *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 (2007). *Native Vegetation Information: Overview of Native Vegetation Spatial Datasets Information Sheet No. 1*. Department of Sustainability and Environment, East Melbourne, Victoria.

DSE (2006) *27 600 ML 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.

Feehan Consulting (2009). *Northern Victorian Irrigation Renewal Project. Waterway Short-listing Report.* Report prepared for Northern Victorian Irrigation Renewal Project.

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.

GMW (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

GMW (2013). *Water Change Management Framework*, Version 3, Goulburn-Murray Water Connections Project, Tatura, Victoria

GMW (2015). *Environmental Watering Plan Review 2015. Comparison of Monitoring Data to Ecological Objectives.* Goulburn-Murray Water, Tatura.

Hydro Environmental (2009). *Northern Victoria Irrigation Renewal Project. Wetland Short-listing Report*. Report prepared for Northern Victoria Irrigation Renewal Project.

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

Macumber, P.G. (2002). *A review of the hydrology of Lake Elizabeth and Lake-Groundwater* interactions. Report prepared for DNRE Kerang.

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

McGuckin, J., Amenta, V., and Pettigrove, V. (1999) *Wetland and Remnant Vegetation Monitoring Torrumbarry East of Loddon 1998-1999*. Prepared by Streamlike Research for the Department of Natural Resources and Environment, Victoria.

Natural Heritage Trust (2001). *Your Wetland Hydrology Guidelines – River Murray South Australia*, Prepared by the Natural Heritage Trust – Murray Darling, Renmark, South Australia

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

Rakali Ecological Consulting (2014). *Kerang Ramsar and other significant wetlands monitoring project 2014*. Report prepared for NCCMA.

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.

SKM (2001). Wetland *Watering and Operational Management Plan for McDonalds Swamp*, Sinclair Knight Merz, Victoria.

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

Appendix A: NVIRP TAC, Wetland workshop participants and GMW Connections Project ETAC

Table A1: NVIRP TAC members - 2009

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 – 17 December 2009

Name	Organisation and Job title
Andrea Joyce	Program Leader – Wetlands and Environmental Flows Department of Sustainability and Environment
Anne Graesser	Manager – Natural Resources Services Goulburn Murray Water
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 North Central CMA
Geoff Sainty	Wetland Specialist Sainty and Associates Pty Ltd
Karen Weaver	Biodiversity and Ecosystem Services Department of Sustainability and Environment
Mark Tscharke	Senior Ranger Parks Victoria
Michelle Bills	Strategic Environmental Coordinator North Central CMA
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

Table A3: GMW Connections Project ETAC members - 2015

Name	Organisation and Job title
Aaron Gay	Regional Manager, Environment and Natural Resources Department of Environment, Water, Land and Planning
Andrea Keleher	Program Manager – Healthy Landscapes Department of Environment, Water, Land and Planning
Bruce Wehner	Ranger Parks Victoria
Carl Walters	Executive Officer SIR Goulburn Broken CMA
Emer Campbell	Executive Manager – MCAR North Central CMA
Neil McLeod	Irrigation Officer – Dairy and Irrigation Department of Economic Development, Jobs, Transport and Resources
Ross Plunkett	Manager Environment and Water Savings GMW Connections Project
Observers	
Chris Solum	Environmental Project Manager GMW Connections Project
Josie Lester	Environmental Project Officer GMW Connections Project

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 GMW Connections Project. 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 (McDonalds Swamp)

- Ross Stanton (G-MW)
- Stan Archard (Archards Irrigation)
- Murray Rhoda and Heath Dunstan (DSE)
- Ken Lancaster (landholder)
- Betty Waterson and Norma Sheridan (Bird Observation and Conservation Australia)

Information provided to the community

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

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

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

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

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

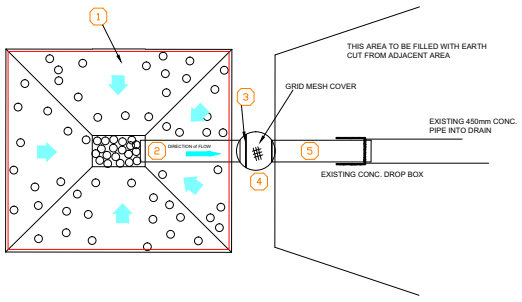
Comments and feedback from participants for McDonalds Swamp

- Originally McDonalds Swamp would have been an ephemeral wetland
    - Only filled during Piccaninny/Barr Creek events when Gunbower Creek was running high.
- It is thought that the River Red Gums in the swamp died in the late period of the 1880s – wet period when salt came up and three year inundation period
- Cumbungi/Phragmites never used to be in the swamp. In the 1980s, they used to aerial spray all the wetlands in the area.
- Since European settlement McDonalds Swamp was full all the time
    - Dredged Piccaninny Creek in the late 60s
    - Irrigation outfall when the channel was running (overflow)
    - From the 1980s State Game Reserve use to supply the wetland when water was available in August (open agreement with the Rural Water Commission)
    - Surrounding land was laser graded
- Summer ecology established in response to unnatural water regime (early 80s) – Cumbungi/Phragmites. They were providing perfect conditions for the species (warm/shallow, nutrient rich water).
- There was a fire 10 years ago (lightning strike in the middle of the wetland)

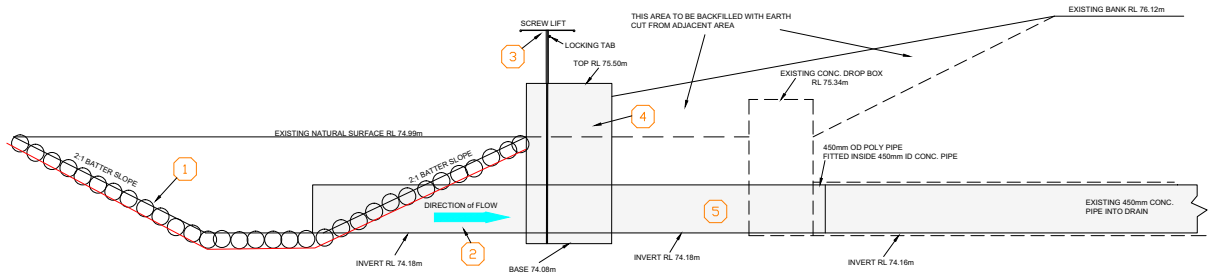
- Previously a very popular wetland for hunting. Management used to ensure there was water in it by the 3rd Saturday in March for duck hunting.
- The outlet is rarely used.
- Grazing in the wetland ceased about 5 or 6 years ago. Controlled grazing is seen as a possible way to maintain vegetation within the wetland and improve its condition.
- This wetland is extremely productive for waterbirds – it provided a different habitat to the permanent Kerang Lakes in the Torrumbarry Irrigation System. This shallow freshwater marsh is ideal for wading birds and providing this habitat for birds is important to consider on a yearly basis.
    - Ibis used to nest in the Club-rush
    - There is high value around the edge of the wetland for wading birds (mudflats)
    - Over 3,000 Teal were observed in the 2009-10 watering event, as well as many Native Hens.
    - Yellow Thornbill, Black Swan, ibis (Straw-necked, Glossy and Sacred), Royal and Yellow Spoonbills, Sea Eagle, lapwings, sandpipers, dotterels, crakes, Cockatiel, Swamp Harrier, and Barn Owl.
    - Swan breeding was prolific. Cygnets died during the last watering event due to the water level dropping. Spring counts are required to monitor breeding events.
    - It is very important to maintain water levels to ensure birds do not abandon their nests.
    - Other species known to occur: Tiger Snake, bats, and macroinvertebrates.
    - There are a lot of foxes in the area.
    - European Carp were introduced.
    - There was agreement on the water regime of filling every year (maintaining the water level where required for waterbird breeding) and allowing to draw-down naturally.
    - It is important to ensure that one of this wetland type goes through a wetting cycle (4-5 swamps could be selected to provide this regime, e.g. Johnsons, Hirds, Lake Murphy)
    - It was mentioned that originally the Murray Flora and Fauna Entitlement ensured this occurred prior to the drought requiring this entitlement to provide water for other areas in Victoria.
- A small local catchment areas that flow into the lake (approximately 100ha)
- Groundwater intrusion has never been a huge issue.
- The clay surface means that the watertable below McDonalds Swamp is lower than it is beyond the wetland.
- A bank is required on the west side of the swamp to prevent water from inundating surrounding land when at full supply level.
- It is important to maintain water and waterfowl for this very productive wetland.

Appendix C: Contour Plan and Capacity Table Archards Irrigation (2010)

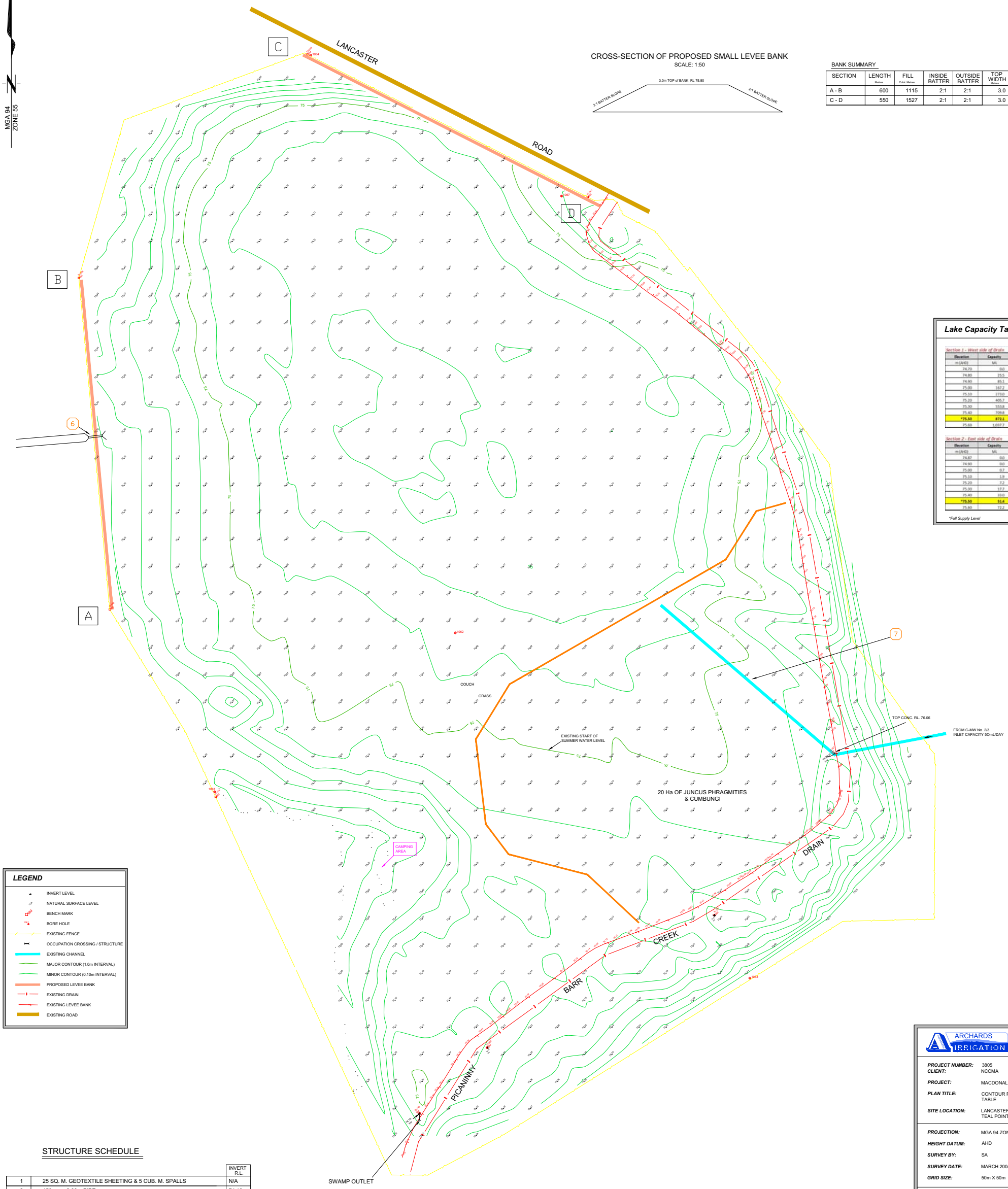
PLAN VIEW OF SWAMP OUTLET
SCALE: 1:50



CROSS-SECTION OF SWAMP OUTLET
SCALE: 1:25



MGA 94
ZONE 55



CROSS-SECTION OF PROPOSED SMALL LEVEE BANK
SCALE: 1:50

BANK SUMMARY

SECTION	LENGTH Metres	FILL Cubic Metres	INSIDE BATTER	OUTSIDE BATTER	TOP WIDTH Metres	GRADE
A - B	600	1115	2:1	2:1	3.0	0
C - D	550	1527	2:1	2:1	3.0	0

Lake Capacity Table

Section 1 - West side of Drain

Elevation m (AHD)	Capacity ML	Surface Area Ha
74.70	0.0	6.0
74.80	25.5	48.2
74.90	85.1	71.6
75.00	167.2	94.6
75.10	271.0	119.3
75.20	405.7	143.6
75.30	553.8	152.3
75.40	709.8	159.5
***75.50**	**872.1**	**164.2**
75.60	1,037.7	166.7

Section 2 - East side of Drain

Elevation m (AHD)	Capacity ML	Surface Area Ha
74.87	0.0	0.0
74.90	0.0	0.3
75.00	0.7	1.0
75.10	1.9	3.0
75.20	7.2	8.4
75.30	17.7	13.1
75.40	33.0	17.1
***75.50**	**51.4**	**19.8**
75.60	72.2	21.8

*Full Supply Level

LEGEND

- INVERT LEVEL
- NATURAL SURFACE LEVEL
- BENCH MARK
- BORE HOLE
- EXISTING FENCE
- OCCUPATION CROSSING / STRUCTURE
- EXISTING CHANNEL
- MAJOR CONTOUR (1.0m INTERVAL)
- MINOR CONTOUR (0.10m INTERVAL)
- PROPOSED LEVEE BANK
- EXISTING DRAIN
- EXISTING LEVEE BANK
- EXISTING ROAD

STRUCTURE SCHEDULE

		INVERT R.L.
1	25 SQ. M. GEOTEXTILE SHEETING & 5 CUB. M. SPALLS	N/A
2	450mm x 2.00m PIPE	74.18
3	1.4m HIGH x 0.45m WIDE DOOR WITH	N/A
	SCREW LIFT AND LOCK DOWN TAB	N/A
4	1.40m x 800mm PIPE WITH GRID MESH COVER	N/A
5	450mm x 2.00m PIPE	74.18
6	400mm PIPE, 6 METRES LONG WITH ONE WAY FLAP	
7	INLET CHANNEL	74.64

0 100 200 300 400m
1 : 2500

ARCHARDS IRRIGATION
P.O. BOX 337
LEITCHVILLE ROAD
COHUNA 3568
PH: 03 5456 3255
FAX: 03 5456 3256
www.archards.com.au
survey@archards.com.au

PROJECT NUMBER:	3805
CLIENT:	NCCMA
PROJECT:	MACDONALD SWAMP
PLAN TITLE:	CONTOUR PLAN & CAPACITY TABLE
SITE LOCATION:	LANCASTER ROAD TEAL POINT 3579
PROJECTION:	MGA 94 ZONE 55
HEIGHT DATUM:	AHD
SURVEY BY:	SA
SURVEY DATE:	MARCH 2004
GRID SIZE:	50m X 50m
SHEET SIZE:	A0
SCALE:	1:2500
DESIGN BY:	SA
DRAWN BY:	DC
LAST AMENDED:	17/02/2010

FILENAME: **3805 McDonalds Swamp.dwg**

Appendix D: Wetland characteristics

Characteristics	Description
Wetland Name	McDonalds Swamp
Wetland ID	7726 344450
Wetland Area	164 ha of a 215 ha crown land reserve
Conservation Status	Bioregionally Important Wetland
Land Manager	State Wildlife Reserve
Surrounding Land Use	Broadacre dryland agriculture
Water Supply	Natural: Piccaninny/Barr Creek Current: Torrumbarry Irrigation System Channel Outfall (2/3) • 300 EC • Capacity of 50 ML/day • Average delivery rate 21 ML/day (approx. 42 days to FSL)
1788 Wetland Classification	Category: Shallow freshwater marsh (<8 months duration, <0.5m depth) Sub-category: n/a
1994 Wetland Classification	Category: Deep freshwater marsh Sub-categories: reed, dead timber
Wetland Capacity	872 ML, *FSL 75.50 m AHD* (Archards Irrigation 2010)
Outfall Volumes	121 ML (04/05) 177 ML (98/99 to 06/07 average)

Appendix E: Flora and fauna species list

Compiled: September 2009

Sources:

Campbell *et al*. (2009)

DSE (2009h)

McGuckin *et al.* (1999)

Saddlier *et al.* (2009)

SKM (2001)

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.

Updated: January 2015

Sources:

eBird Website (2014)

North Central Catchment Management Authority bird monitoring records (2014).

Common Name	Scientific Name
Fauna – native	
Australasian Grebe	*Tachybaptus novaehollandiae*
Australasian Pipit	*Anthus novaeseelandiae*
Australasian Shoveler	*Anas rhynchotis*
Australian Hobby	*Falco longipennis*
Australian Magpie	*Gymnorhina tibicen*
Australian Painted Snipe	*Rostratula australis*
Australian Pelican	*Pelecanus conspicillatus*
Australian Raven	*Corvus coronoides*
Australian Reed Warbler	*Acrocephalus australis*
Australian Shelduck	*Tadorna tadornoides*
Australian Spotted Crake	*Porzana fluminea*
Australian White Ibis	*Threskiornis molucca*
Australian Wood Duck	*Chenonetta jubata*
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-faced Honeyeater	*Entomyzon cyanotis*
Brolga	*Grus rubicunda*
Brown Falcon	*Falco berigora*
Chestnut Teal	*Anas castanea*
Clamorous Reed Warbler	*Acrocephalus stentoreus*
Cockatiel	*Nymphicus hollandicus*
Collared Sparrowhawk	*Accipiter cirrhocephalus*
Common Greenshank	*Tringa nebularia*
Crested Pigeon	*Ocyphaps lophotes*
Crimson Rosella	*Platycercus elegans*
Darter	*Anhinga novaehollandiae*
Dusky Moorhen	*Gallinula tenebrosa*
Eastern Great Egret	*Ardea modesta*
Eastern Rosella	*Platycercus eximius*
Eurasian Coot	*Fulica atra*
Freckled Duck	*Stictonetta naevosa*

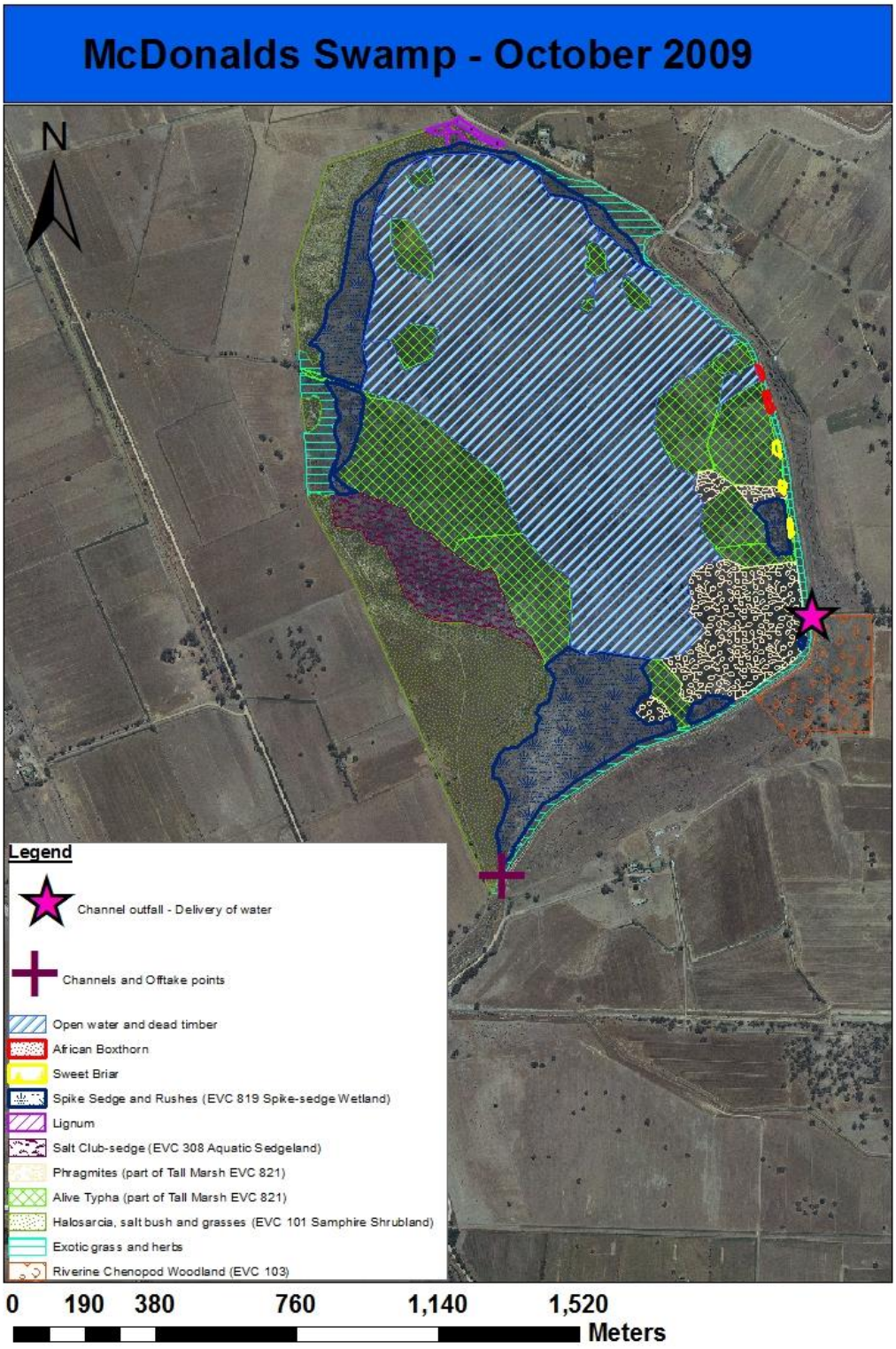
Common Name	Scientific Name
Galah	*Eolophus roseicapilla*
Glossy Ibis	*Plegadis falcinellus*
Golden-headed Cisticola	*Cisticola exilis*
Great Cormorant	*Phalacrocorax carbo*
Great Crested Grebe	*Podiceps cristatus*
Grey Teal	*Anas gracilis*
Grey-crowned Babbler	*Pomatostomus temporalis*
Hardhead	*Aythya australis*
Hoary-headed Grebe	*Poliocephalus poliocephalus*
Intermediate Egret	*Ardea intermedia*
Laughing Kookaburra	*Dacelo novaeguineae*
Little Black Cormorant	*Phalacrocorax sulcirostris*
Little Grassbird	*Megalurus gramineus*
Little Pied Cormorant	*Microcarbo melanoleucos*
Little Raven	*Corvus mellori*
Magpie-lark	*Grallina cyanoleuca*
Marsh Sandpiper	*Tringa stagnatilis*
Masked Lapwing	*Vanellus miles*
Mistletoebird	*Dicaeum hirundinaceum*
Musk Duck	*Biziura lobata*
Nankeen Kestrel	*Falco cenchroides*
Nankeen Night Heron	*Nycticorax caledonicus*
Noisy Miner	*Manorina melanocephala*
Pacific Black Duck	*Anas superciliosa*
Pacific Gull	*Larus pacificus*
Pied Butcherbird	*Cracticus nigrogularis*
Pink-eared Duck	*Malacorhynchus membranaceus*
Plumed Whistling-Duck	*Dendrocygna eytoni*
Purple Swamphen	*Porphyrio porphyrio*
Red-kneed Dotterel	*Erythrogonys cinctus*
Red-rumped Parrot	*Psephotus haematonotus*
Royal Spoonbill	*Platalea regia*
Sacred Kingfisher	*Todiramphus sanctus*
Sharp-tailed Sandpiper	*Calidris acuminata*
Silver Gull	*Larus novaehollandiae*
Singing Honeyeater	*Lichenostomus virescens*
Straw-necked Ibis	*Threskiornis spinicollis*
Striated Pardalote	*Pardalotus striatus*
Superb Fairy-wren	*Malurus cyaneus*
Swamp Harrier	*Circus approximans*
Tree Martin	*Hirundo nigricans*
Wedge-tailed Eagle	*Aquila audax*
Welcome Swallow	*Hirundo neoxena*
Whiskered Tern	*Chlidonias hybridus*
Whistling Kite	*Haliastur sphenurus*
White-bellied Sea-Eagle	*Haliaeetus leucogaster*
White-breasted Woodswallow	*Artamus leucorynchus*
White-faced Heron	*Egretta novaehollandiae*
White-fronted Chat	*Epthianura albifrons*
White-necked Heron	*Ardea pacifica*
White-plumed Honeyeater	*Lichenostomus penicillatus*
Willie Wagtail	*Rhipidura leucophrys*
Yellow Thornbill	*Acanthiza nana*
Yellow-billed Spoonbill	*Platalea flavipes*
Yellow-rumped Thornbill	*Acanthiza chrysorrhoa*
Zebra Finch	*Taeniopygia guttata*
Fauna - exotic	
Common Starling	*Sturnus vulgaris*
European Carp	*Cyprinus carpio*
House Sparrow	*Passer domesticus*
Flora - native	
Gold Rush	*Juncus flavidus*

Common Name	Scientific Name
Berry Saltbush	*Atriplex semibaccata*
Black Box	*Eucalyptus largiflorens*
Black Cotton-bush	*Maireana decalvans*
Blackseed Glasswort	*Halosarcia pergranulata subsp. pergranulata*
Black Roly-poly	*Sclerolaena muricata*
Branching Groundsel	*Senecio cunninghamii var. cunninghamii*
Bristly Wallaby-grass	*Austrodanthonia setacea*
Common Blown-grass	*Agrostis avenacea*
Common Duckweed	*Lemna minor*
Common Reed	*Phragmites australis*
Common Spike-sedge	*Eleocharis acuta*
Common Wallaby-grass	*Austrodanthonia caespitosa*
Cumbungi	*Typha orientalis*
Dense Crassula	*Crassula colorata*
Dock	*Rumex sp.*
Fennel Pondweed	*Potamogeton pectinatus*
Finger Rush	*Juncus subsecundus*
Flat Spike-sedge	*Eleocharis plana*
Floodplain Fireweed	*Senecio campylocarpus*
Grassland Wood-sorrel	*Oxalis perennans*
Hairy Willow-herb	*Epilobium hirtigerum*
Hedge Saltbush	*Rhagodia spinescens*
Knob Sedge	*Carex inversa*
Lemon Beauty-heads	*Calocephalus citreus*
Nardoo	*Marsilea sp.*
Narrow-leaf Dock	*Rumex tenax*
Nitre Goosefoot	*Chenopodium nitrariaceum*
Nitre-bush	*Nitraria billardierei*
Pacific Azolla	*Azolla filiculoides*
Pale Goodenia	*Goodenia glauca*
Pale Plover-daisy	*Leiocarpa leptolepis*
Peppercress	*Lepidium sp.*
River Club-sedge	*Schoenoplectus validus*
River Red Gum	*Eucalyptus camaldulensis*
Ruby Saltbush	*Enchylaena tomentosa var. tomentosa*
Rush	*(#14) Juncus* sp.
Rush	*(#27) Juncus* sp.
Saloop	*Einadia hastata*
Salt Club-sedge	*Bolboschoenus caldwellii*
Sieber Crassula	*Crassula sieberiana*
Slender-fruit Saltbush	*Atriplex leptocarpa*
Small Knotweed	*Polygonum plebeium*
Small Loosestrife	*Lythrum hyssopifolia*
Spider Grass	*Enteropogon acicularis*
Spiny Lignum	*Muehlenbeckia horrida* subsp. *horrida*
Star Cudweed	*Euchiton involucratus s.l.*
Tall Spike-sedge	*Eleocharis sphacelata*
Tangled Lignum	*Muehlenbeckia florulenta*
Thin Duckweed	*Spirodela punctata*
Tussock Rush	*Juncus aridicola*
Upright Water-milfoil	*Myriophyllum crispatum*
Water-milfoil	*Myriophyllum sp.*

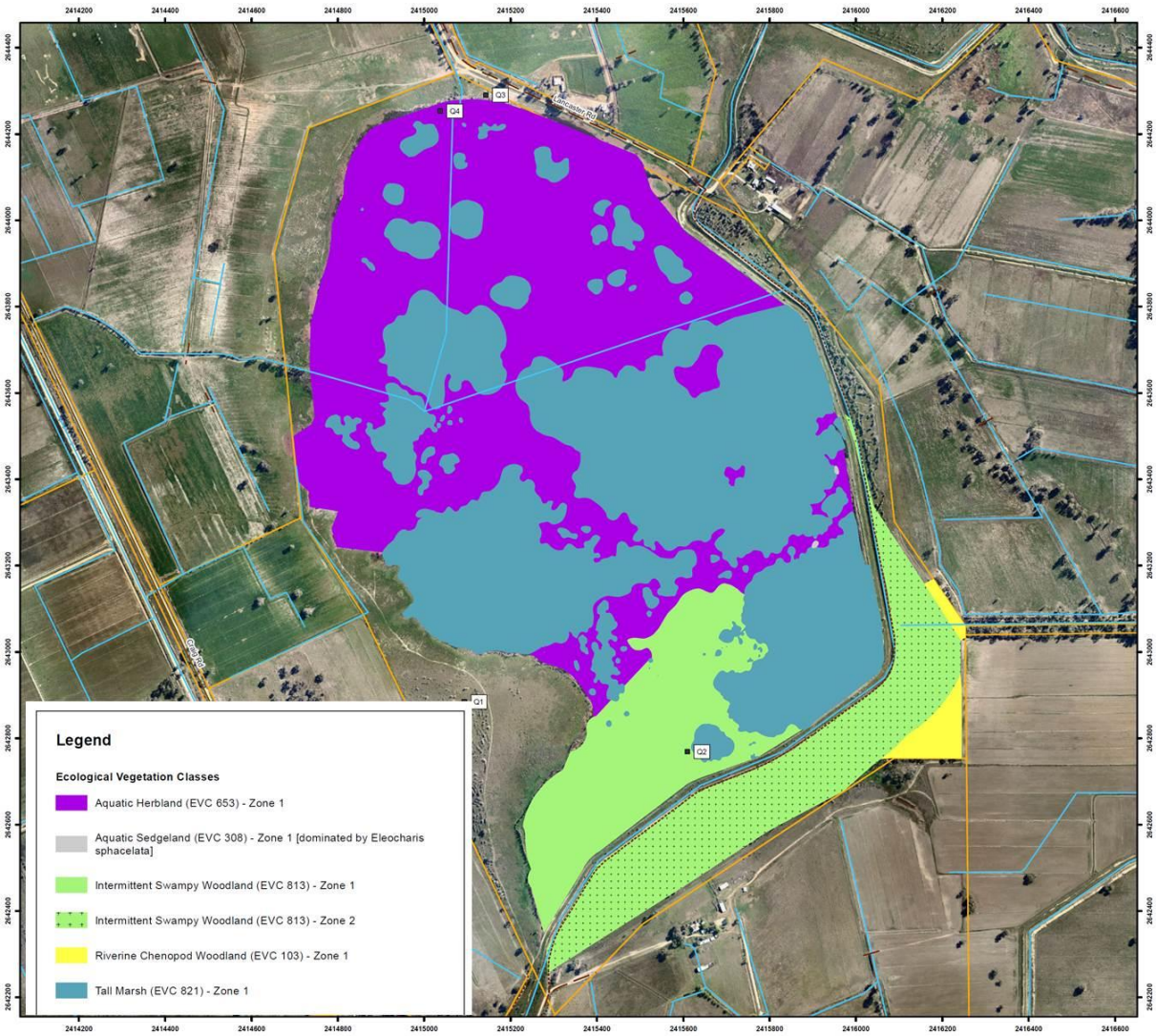
Common Name	Scientific Name
Water-pepper	*Persicaria hydropiper*
Windmill Grass	*Chloris truncata*
Flora - exotic	
African Boxthorn	*Lycium ferocissimum*
Barley Grass	*Hordeum sp.*
Burr Medic	*Medicago polymorpha*
Celery Buttercup	*Ranunculus scleratus ssp. scleratus*
Chingma Lantern	*Abutilon theophrasti*
Cluster Clover	*Trifolium glomeratum*
Common Heliotrope	*Heliotropium europaeum*
Common Sow-thistle	*Sonchus oleraceus*
Curled Dock	*Rumex crispus*
Fat Hen	*Chenopodium album*
Ferny Cotula	*Cotula bipinnata*
Flat Spurge	*Chamaesyce drummondii*
Fog-fruit	*Phyla canescens*
Great Brome	*Bromus diandrus*
Horehound	*Marrubium vulgare*
Jointed Rush	*Juncus articulatus*
London Rocket	*Sisymbrium irio*
Onion Weed	*Asphodelus fistulosus*
Ox-tongue	*Helminthotheca echioides*
Paterson's Curse	*Echium plantagineum*
Perennial Rye-grass	*Lolium perenne*
Prickly Lettuce	*Lactuca serriola*
Rat's-tail Fescue	*Vulpia myuros*
Sea Barley-grass	*Critesion marinum*
Small-flower Mallow	*Malva parviflora*
Small Ice-plant	*Mesembryanthemum nodiflorum*
Spear Thistle	*Cirsium vulgare*
Sweet Briar	*Rosa rubiginosa*
Toowoomba Canary-grass	*Phalaris aquatica*
Variegated Thistle	*Silybum marianum*
Water Buttons	*Cotula coronopifolia*
Water Couch	*Paspalum distichum*
Wireweed	*Polygonum arenastrum*
Wimmera Rye-grass	*Lolium rigidum*

Appendix F: Vegetation composition maps

Vegetation composition mapping 2009



Vegetation composition mapping 2014



Appendix G: Hydrology (SWET OUTPUT)

set	Wetland Name	McDonalds Swamp							
		Degrees	Degrees	Minutes					
set	Latitude	-35.70278	-35.00	42.1667					
set	Longitude	144.06462	144.00	3.8769					
		Metres (AHD)							
	Altitude	75.5						Runoff coefficient	
		ha	m^2	ML/ha/yr	ML/yr	Rainfall	Total (ML)	Mean	Max.
set	Local contributing catchment area	100	1000000	0.2	20	354	354	0.057	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	20							

	Management parameters	Day	Month	Start day
adjust	Earliest start to fill	1	7	182
adjust	Latest start to fill	31	12	
adjust	Duration wet cycle - includes filling	122	4	
adjust	Duration dry cycle - includes drawdown	244	8	
set	Start condition	Dry		Years
set	Maximum wet-dry cycle length			2

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

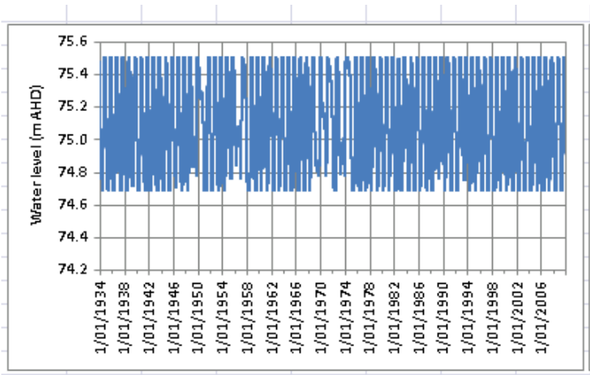
		Day	Month
adjust	Irrigation year start	1	7

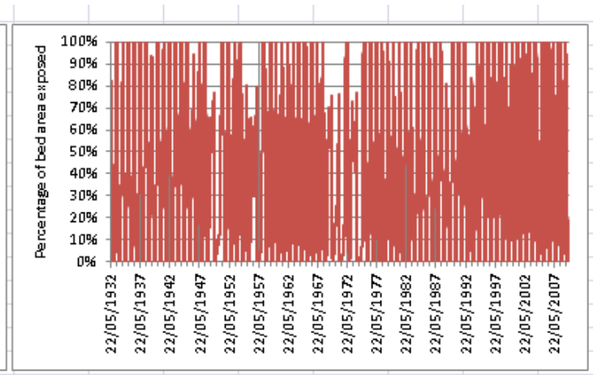
		Elevation	Volume	Area
adjust	Target level	75.5	872100	1642000
		Elevation	Volume	Area
set	Wetland spill level	75.5	872100	1642000
		Elevation	Tolerance for drying (m)	
adjust	Lowest wetland level	74.69	0.1	
			1 = Pan; 2 = Modelled	
choose	Factored Pan evaporation or modelled ET method?		2	

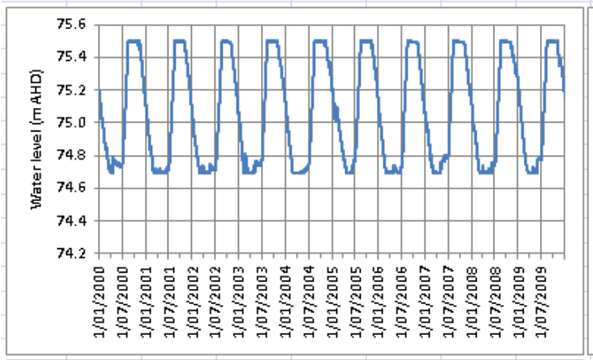
RESULT

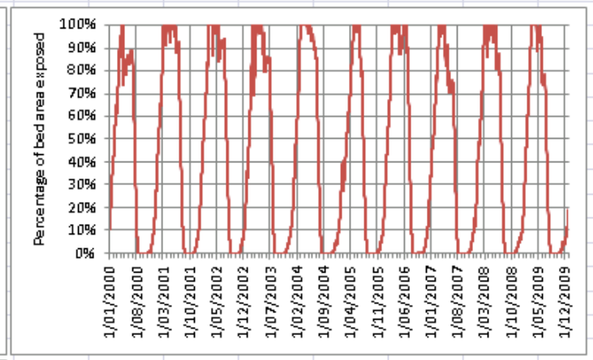
	ML/year	P95 (ML/yr)	Years with no inflow
Mean long-term annual artificial water inflows	1,298	1,545	4 in 118 years
	ML	No. Periods	Record length (years
Average water inflows for filling periods	1,345	115	118
Drawdowns over record (number of)	115		
Drawdowns not fully dried out (number of)	0		
Drawdowns not fully dried out (percentage)	0%		
95th percentile duration of full period (months)	2.8		
50th percentile duration of full period (months)	2.3		

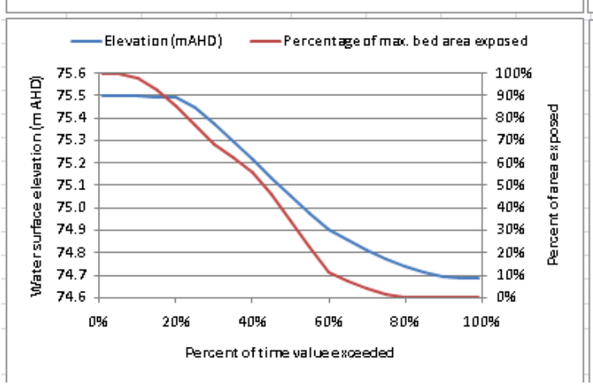
Fill cycle length (yr)	No. cycles
1	111
2	4
3	
4	
5	
6	
7	
8	
9	
10	

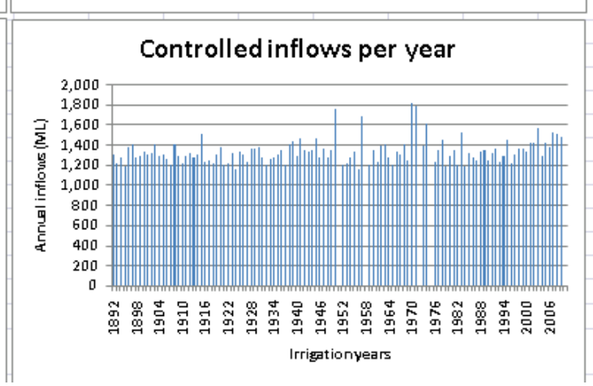












Appendix H: Preliminary leakage and seepage loss contribution calculations

Wetland	Wetland within 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)
McDonalds Swamp	No (820 m)	n/a	n/a	No. 5 main channel	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*)

Chanel width (m)	Chanel half-width (m)	Seepage Rate in mm/day			
		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		
Limited water availability (e.g. insufficient or no environmental water allocation)	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 and wetland phase.
Climatic variability	Variability in water availability (e.g. wet seasons during a planned dry phase)	Adaptive management of water regime and delivery options as above. Re-model volumes required in light of changing climatic conditions 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. Encroachment of nutrient tolerant vegetation *Typha* sp. and *Phragmites* sp. Excessive algal growth	Monitoring of groundwater levels, salinity and nutrient inputs in conjunction with a regular water quality monitoring program (Section 8 and Appendix J). Adaptively manage water regime and delivery.
Groundwater intrusion or discharge to low-lying surrounding area resulting from elevated groundwater levels[14]	Poor vegetation health Limited regeneration and dominance of salt tolerant species Unsuitable habitat for waterbirds and food sources	Monitoring of groundwater levels and salinity within wetland and surrounding area (Section 8 and Appendix J). Adaptive management of water regime.
Lack of connection between wetland, river and floodplain	Altered flow regime (continued lack of flood flows) Lack of flora and fauna sources for repopulation	Investigate opportunities to reconnect McDonalds Swamp to the river and floodplain.
Flooding of adjacent landholders	Community angst Liability	Regularly monitor rainfall and climate data and adapt water delivery to account for potential flood events. Re-model volumes required in light of changing climatic conditions and wetland phase. Consider constructing a levee on the west side of the wetland to prevent inundation of adjacent land when filling to FSL (pers. comm. Stan Archard [Archards Irrigation],

[14] Under current conditions of low groundwater levels, this is unlikely. However, if conditions where to change and groundwater levels rose there would be a risk of saline groundwater intrusion into the wetland or discharge onto low-lying adjacent land (Bartley Consulting 2009).

Risks/limiting factors	Impacts	Mitigation measures
		18 January 2010).
Ecological Response		
Fluctuating groundwater height and salinity levels	Saline groundwater intrusion or discharge onto low-lying surrounding land	Groundwater monitoring and adaptive management of desired water regime (Section 8 and Appendix J).
Unreliable supply of food/nesting sites	Limited occurrences of waterbirds	Seasonal water delivery, regular monitoring and adaptive management of water regime to ensure suitable habitat is provided throughout the breeding event (Section 8 and Appendix J).
Lag time between wetland watering and bird breeding	No successful breeding events	Seasonal water delivery, regular monitoring (spring assessments) and adaptive management of water regime (Section 8 and Appendix J). Top-ups may be required to prolong inundation period and complete bird breeding events.
Encroachment or dominance of native flora species	Monoculture of *Typha* sp. and *Phragmites* sp.	Active management (spraying, slashing, crash grazing etc)
	Loss in species diversity	
	Habitat loss	
	Watering events prove unproductive for waterbirds	Seasonal water delivery, regular monitoring and adaptive management of water regime (Section 8 and Appendix J)
Proliferation of pest plants and animals[15]	Reduced habitat and resource availability	Regular monitoring, active management (weed and pest control) (Section 8 and Appendix J)
	Predation	
	Limited establishment of native vegetation	
Lack of seedbank viability	Monoculture of *Typha* sp. and *Phragmites* sp.	Monitoring (e.g. IWC) and adaptive management (Section 8 and Appendix J). Fluctuation of water levels will be required to support River Red Gum germination. Consider seeding if necessary.
	Emergence of unexpected native or exotic species	
	Restricted regeneration	
	Limited regeneration and dominance of salt tolerant species	
High soil salinity	Poor vegetation health	Monitoring and adaptive management of desired water regime to reduce potential groundwater intrusion or discharge to low-lying surrounding areas (Section 8 and Appendix G).
	Limited regeneration and dominance of salt tolerant species	
Other		
Recreational pressures e.g. hunting increases in response to water event	Loss of non-game species	Monitoring of waterbird numbers and diversity (Section 8 and Appendix J). Reporting of information to relevant bodies including Field and Game and DSE (particularly the occurrence of listed species prior to opening of the hunting season).

[15] May result from reductions in pest plant and animal management on adjoining land to changed management practices (e.g. absentee landholders).

Risks/limiting factors	Impacts	Mitigation measures
Fire	Habitat and resource loss	Active management, monitoring (e.g. IWC) and adaptive management (Section 8 and Appendix J)
	Deteriorating water quality	

Appendix J: Monitoring program recommendations

It is not a requirement of the GMW Connections Project to provide long-term condition or intervention monitoring nor does this document represent a comprehensive management plan for McDonalds Swamp. 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 water regime (Bartley Consulting 2009).

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 McDonalds Swamp.

Vegetation condition and distribution

A number of photo points and objectives for long term vegetation monitoring need to be established for McDonalds Swamp 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 McDonalds Swamp, are assessed every five years. A condition assessment of McDonalds Swamp using the statewide Index of Wetland Condition (IWC) method was conducted as part of this project. The IWC not only provides useful information on the condition and distribution of vegetation but also highlights indicators of altered processes (threatening processes). The results of this assessment have been provided are to be provided in following versions. It is recommended that an IWC assessment be completed for McDonalds Swamp every 5 years. However, this may need to be undertaken sooner depending on the rate of response to water (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 McDonalds Swamp is currently conducted by DEDJTR 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 desired water 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 McDonalds Swamp and to enhance the quality of data being collected (Bartley Consulting 2009).

Table J1: Additional groundwater monitoring recommendations (Bartley Consulting 2009)

Target	Recommendation
Long-term groundwater monitoring	A review of the groundwater-related aspects of the site, including a re-assessment of environmental risks, should be undertaken in the medium term review cycle (at least every seven years) and sooner if the water approach changes or regional groundwater levels rise.

Target	Recommendation
	The impact of the adopted water regime should be reviewed and assessed in accordance with the requirements of the environmental monitoring plan. Subject to data availability, this 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	Install data loggers to record surface water level and salinity in the wetland.
	Install data loggers (water level and EC) in selected groundwater bores, to provide data throughout the wetting and drying cycle at the site.
	Survey bed elevation, the elevation of the surface water gauge, and the ground surface and measurement point elevation of current monitoring bores at the site.
	Establish and use rating tables to assist recording water level and volume.
	Investigate the condition of current bore DPI 60175 (reportedly dry) and if necessary, install a new shallow bore and deep bore at that location.
	Record the inflow and outflow volumes during the watering event.
Breadth of data collected	Regularly liaise with neighbouring landholders to understand their water use and irrigation practices, and how these change over time.
	Monitor neighbouring areas that are considered susceptible to salinisation or waterlogging.
	Replace DPI bore 60173 (apparently the bore no longer exists), and also install a deeper bore at that location.;
	Continue monitoring at Red Gum Swamp as it provides background data in a similar setting, and potentially under a different water regime.
	Install shallow and deep groundwater monitoring bores on the eastern side of the site on either side of Piccaninny Creek.
	Assess 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 desired 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 McDonalds Swamp and should be updated following regular monitoring.

Table J2: Components of vegetation intervention monitoring

Component	Target	Method	Objective
Vegetation distribution	Tall Marsh (and associated grasses), Aquatic Spike-sedge and Salt Club-sedge, Lignum, River Red Gum, Riverine Chenopod Woodland	• Distribution mapping • Photo points	Habitat objectives, species/community objectives
Vegetation condition		• Photo points	Habitat objectives
Species diversity	Additional species with a focus on aquatic and amphibious species	• Species list comparison	Habitat objectives

Waterbirds

The diversity and abundance of waterbirds at McDonalds Swamp 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.

Waterbird monitoring is currently undertaken by DELWP under a contract with NCCMA. 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 McDonalds Swamp 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, 2.1
Waterbird abundance			Habitat objectives, 2.1
Habitat availability	Open water (including aquatic and amphibious species), mudflats, tall marsh vegetation, Aquatic Spike-sedge and Salt Club-sedge, Lignum, River Red Gum, Riverine Chenopod Woodland	• Undertaken in conjunction with vegetation monitoring	Habitat objectives, 2.1, 2.2
Breeding populations	Masked Lapwing, Black Swan, Black-winged Stilt, Glossy Ibis, Grey Teal, Royal Spoonbill	• Nest surveys (Baldwin *et al*. 2005)	Habitat objectives, 2.1

Fish and Macroinvertebrates

It is recommended that the response of fish 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 McDonalds Swamp 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)	2.1, 2.2
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, 2.2, 2.3
	pH	pH metre		
	Turbidity	Turbidity metre		
	Dissolved oxygen	Oxygen metre		
	Nutrients	Laboratory analysis		

Appendix K: Contour and vegetation map

McDonalds Swamp

Contours (not available at time of printing) and Vegetation

Legend

Watercourse

Type

- River
- Stream
- Channel
- Connector

Roads

- Freeway
- Highway
- Major Road
- Arterial Road
- Road
- Residential Street
- Track
- Parcel

Vegetation - MDFRC 2009

Exotic

- Sweet Briar
- Exotic grass and herbs
- African Boxthorn

Native

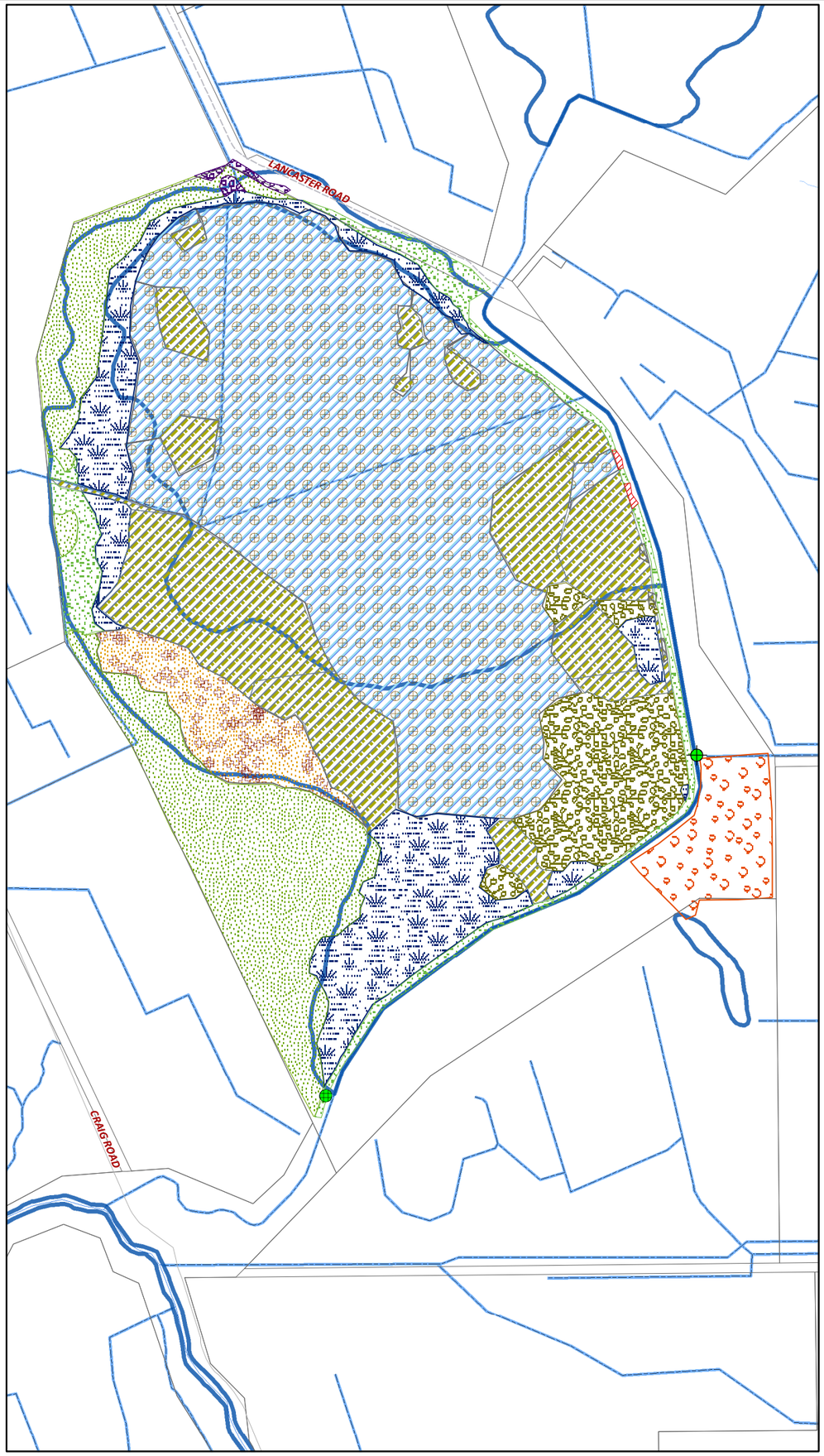
- Scattered Lignum
- Alive Cumbungi (part of Tall Marsh EVC 821)
- Spike Sedge and Rushes (EVC 819 Spike Sedge Wetland)
- Salt Club-sedge (EVC 308 Aquatic Sedgeland)
- Riverine Chenopod Woodland (EVC 103)
- Common Reed (part of Tall Marsh EVC 821)
- Blackseed Glasswort, salt bush and grasses

Infrastructure

- Channel outfall
- Outlet and Offtake points

Waterbodies

- Open water and dead timber



Meters

360 180 0 360

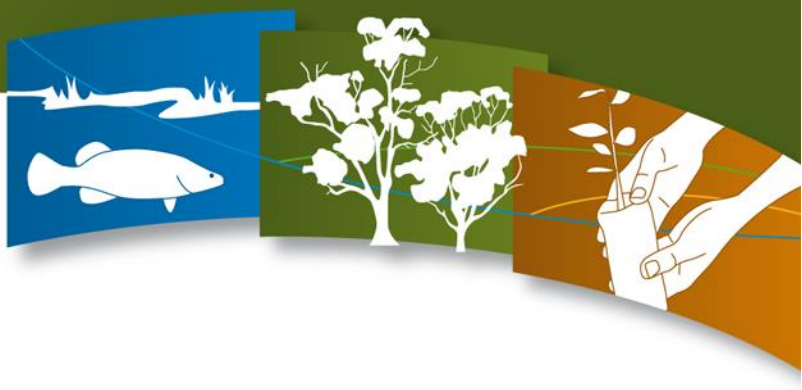
1:11,000

N W E S

Victoria
The Place To Be

NORTH CENTRAL
Catchment Management Authority
Connecting Rivers, Landscapes, People

T:\GDC\MXD\PROJECTS\NORTH_CENTRAL_CMA\STRATEGY\EWPS\NC_EWPs_MDFRC_DATA_LakeMeran



NORTH CENTRAL
Catchment Management Authority
Connecting Rivers, Landscapes, People

Connecting Rivers, Landscapes, People