JOHNSON SWAMP

ENVIRONMENTAL WATERING PLAN

NORTH CENTRAL
Catchment Management Authority
Connecting Rivers, Landscapes, People

PREPARED FOR THE
NORTHERN VICTORIA IRRIGATION RENEWAL PROJECT

NVIRP

August 2009

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Front cover photo: Johnson Swamp 2009, North Central CMA

The Johnson 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.

Written by Michelle Bills and Emer Campbell (North Central CMA).

EXECUTIVE SUMMARY

The Johnson Swamp Environmental Watering Plan (EWP) documents the approach to mitigating the potential impacts of the Northern Victoria Irrigation Renewal Project (NVIRP) due to automation of the Torrumbarry 4/7/2 channel that outfalls into Johnson Swamp.

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

Defining the Johnson Swamp watering requirements

Johnson Swamp is a wetland of international and national significance being part of the Kerang Wetlands Ramsar site and listed on the Directory of Important Wetlands in Australia. It has the potential to support a significant diversity and abundance of invertebrates, waterbirds and flora species, e.g. regularly supporting large numbers of waterfowl, Black Duck and White Ibis.

Part of the Murray Flora and Fauna Bulk Entitlement has frequently been utilised for Johnson Swamp to provide a drought refuge for waterbirds. However, over the past decade, Johnson Swamp has experienced more frequent drying phases due the drought, increased efficiencies in the irrigation system and the lack of availability of environmental water.

An overall goal has been developed in light of the values the wetland supports and potential risk factors that need to be managed.

Johnson Swamp goal
To provide a watering regime that supports a mosaic of plant communities including Lignum/Black Box and open water which provides key habitat for a diverse range of waterbirds.

The relationships between the various wetland values have been described by relating ecological objectives to hydrological objectives, and describing the overall watering regime required to achieve the goal for the wetland.

Overall wetland watering regime:
Fill wetland to capacity one in five years and ensure inundation period of Lignum/Black Box areas does not exceed two to three months. Dependant on evaporation and seepage, top-up/provide smaller volume in the following year to maintain inundation of the open water assemblage (to at least 30cm). Completely dry the following year.

Hydrology assessment

The volumes of water required to provide the recommended watering regime for Johnson Swamp have been assessed.

In year one, Johnson Swamp is filled to capacity to inundate the Black Box/Lignum area with top-ups provided to maintain the submerged aquatic assemblage area. This area is maintained for an additional six months in year two. The volume required to fill the wetland areas and counteract evaporation for year one and two are 3005 ML and 1067 ML respectively. In the second half of year two, the wetland will begin its drying phase.

Although surface water inflows to Johnson Swamp and rainfall will vary considerably from year to year depending on seasonal conditions, estimates have been calculated based on the annual average rainfall. These are 652 ML/year (rainfall directly falling on wetland) and 61 ML/year (surface run-off). Therefore, in an average year (accounting for all significant inflows and losses) the total volume required to fill Johnson Swamp and maintain the open water assemblage area for 12 months, would be reduced to 2444 ML/year and 992 ML for six months of year two.

Identification of the NVIRP mitigation water

Mitigation water is defined as the volume of water required to ensure no net impacts due to the project on high environmental values. A process for calculation of mitigation water based on the best available information has been developed and applied to Johnson Swamp. This process involved the application of a series of steps:

Step 1: Quantifying the hydrological characteristics of the wetland

Step 2: Identifying the potential benefits of the outfall water

Step 3: Applying a set of criteria to determine whether all or part of the outfall water needs to be set aside to support the environmental values

Step 4: Calculating the volume of mitigation water with respect to the proposed wetland watering regime

Step 5: Calculating the net savings (outfall water less mitigation water)

The assessment process for calculation of mitigation water for Johnson Swamp suggests that mitigation water is not required to maintain the environmental values of the wetland. Due to the low volumes of outfall water supplied to the wetland over the past 10 years in comparison to the volumes required to support the wetland's environmental values, it is reasoned that outfalls are not contributing significantly to supporting high environmental values at the site and therefore, there is no requirement on NVIRP to provide mitigation water for the wetland.

Potential risks and adverse impacts associated with the recommended watering regime

Identification of the potential risks and limiting factors associated with the provision of the recommended watering regime for Johnson Swamp is important. The potential risks or limiting factors and impacts that may result from the implementation of, or in association with, the recommended watering regime have been identified. For example, if Johnson Swamp is left in a dry (or predominantly dry) state, it may accumulate and retain relatively high salt levels without sufficient water to flush it into the groundwater system, which may impact on plant species composition and health.

Infrastructure requirements

Delivery of water at appropriate times and in the required quantities is dependent on having appropriate infrastructure and access to spare channel capacity when required. The Johnson Swamp outfall structure has a delivery capacity of 70 ML/day which equates to a minimum of 20 days to fill the wetland from dry.

Potential upgrade options to improve operational management of Johnson Swamp include:

- The replacement of the existing drop-bar outfall structure to a fully automated structure. A carp screen is also recommended when upgrading the outfall structure.
- Upgrade of the outlet structure to Pyramid Creek, to a versatile structure to enable both delivery and drainage.

Adaptive management framework

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

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 environmental watering plans have been defined. A framework for operational management outlining the relevant roles and responsibilities has also been developed to describe the decision-making process required to coordinate implementation of the recommended watering regime for Johnson Swamp.

The Johnson Swamp EWP has been developed utilising the best available information. However, a number of information and knowledge gaps which have been identified in the document may impact on the recommendations and/or information presented.

CONTENTS PAGE

ACKNOWLEDGEMENTS

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

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

- Rob O'Brien (Department Primary Industries)
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- Geoff Sainty (Sainty Associates)
- Ross Stanton, Lester Haw, Paul Saunders and Brendan Espagne (Goulburn-Murray Water)
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- Mark Tscharke (Parks Victoria)
- Greg Wood (previous adjoining landholder)
- Chris Coleborn (Birds Australia Member)
- Ross Plunkett, Chris Solum and Paul Lacy (NVIRP)
- NVIRP TAC (listed in Appendix A, Table A1)
- Wetland workshop attendees (listed in Appendix A, Table A2)
- Expert Panel: Brett Lane (BL&A), Terry Hillman (Hillman *et al*.) and Peter Alexander (Hydro Environmental)
- Melissa Donaldson, Angela Gladman, Rohan Hogan, Rebecca Horsburgh, Sandra Volk and Amanda McClaren (North Central CMA).

In particular, we would like to thank Rob O'Brien (DPI) who has tirelessly worked with us to complete the EWP and whose knowledge of wetlands in the Kerang region is unsurpassed.

ABBREVIATIONS

ANCA	Australian Nature Conservation Agency
AUSRIVAS	Australian River Assessment System
BE	Bulk Entitlement
Bonn	Convention on the Conservation of Migratory Species
CAMBA	China–Australia Migratory Bird Agreement
DCFL	Department of Conservation Forests & Lands
DEWHA	Department of Environment, Water, Heritage and the Arts
DPCD	Department of Planning and Community Development
DSE	Department of Sustainability and Environment
EVC	Ecological Vegetation Class
EWH	Environmental Water Holder
EWP	Environmental Watering Plan
GIS	Geographic Information Systems
GL	Giga Litre (one billion litres)
GMID	Goulburn Murray Irrigation District
G-MW	Goulburn-Murray Water
JAMBA	Japan–Australia Migratory Bird Agreement
North Central CMA	North Central Catchment Management Authority
NVIRP	Northern Victoria Irrigation Renewal Project
PIRVIC	Primary Industries Research Victoria
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

1. Northern Victoria Irrigation Renewal Project

The Northern Victoria Irrigation Renewal Project (NVIRP) is a $2 billion works program to modernise ageing irrigation infrastructure across the Goulburn-Murray Irrigation District (GMID) and to save water lost through leakage, 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 450 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 from the NVIRP are considered a 'loss' to the irrigation system, in some cases this operating regime provides incidental benefits to environmental assets (SKM 2008).

1.1 Decision under the *Environmental Effects Act 1978*

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

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

NVIRP have developed a Water Change Management Framework (WCMF, July 2009) in response to this condition. The framework outlines the processes and methodologies for preparing Environmental Watering Plans to mitigate potential impacts on wetlands and waterways at risk from the implementation of the NVIRP through adaptive water management (NVIRP 2009).

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

1.2 Water Change Management Framework

The Water Change Management Framework (NVIRP 2009) sets out the overarching principles with respect to environmental management for the operation of the modified GMID. These principles include:

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

As part of this, the NVIRP Environmental Referrals process assessed Stage 1 (upgrade of the backbone and connections) of the NVIRP in relation to operational impacts on waterways, wetlands and regional groundwater from increased system efficiencies such as changes in channel outfalls, delivery patterns and reductions in leakage and seepage.

The NVIRP Environmental Referrals process prioritised 10 wetlands and 17 rivers (to be refined) with significant environmental values that may be impacted by an 85% reduction in channel outfalls across the GMID. The 10 wetlands are:

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

The above wetlands are located within the North Central CMA region and require the development of an Environmental Watering Plan. Three (Johnson Swamp, Lake Murphy and Lake Elizabeth) are required before the operation of the NVIRP works in the 2009-2010 irrigation season.

1.3 Purpose and scope of Environmental Watering Plans

The EWPs are the primary means by which the commitment of no net environmental loss will be achieved for water savings projects (NVIRP 2009). Each EWP will:

- identify environmental values of the wetland
- identify the water required to protect the environmental values
- define the environmental watering regime and the sources of water
- identify the infrastructure requirements
- draft protocols for ongoing water supply
- identify management responsibilities.

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

1.4 Development process

The Johnson Swamp EWP was developed in collaboration with key stakeholders including G-MW, NVIRP, DSE, Parks Victoria and DPI according to the process outlined in Figure 1. A number of tasks were undertaken to develop the EWP, as follows:

- scoping and collating information
- defining ecological objectives and associated water requirements
- identifying risks and threats
- assessing infrastructure requirements
- developing recommendations on governance arrangements and adaptive management
- consulting and engaging stakeholders and adjacent landholders.

Following development, EWPs will be reviewed by the DSE Approvals Working Group (membership comprised of departmental representatives) and the Expert Review Panel (Jane Roberts, Terry Hillman and Denis Flett) prior to sign-off by the Minister for Water.

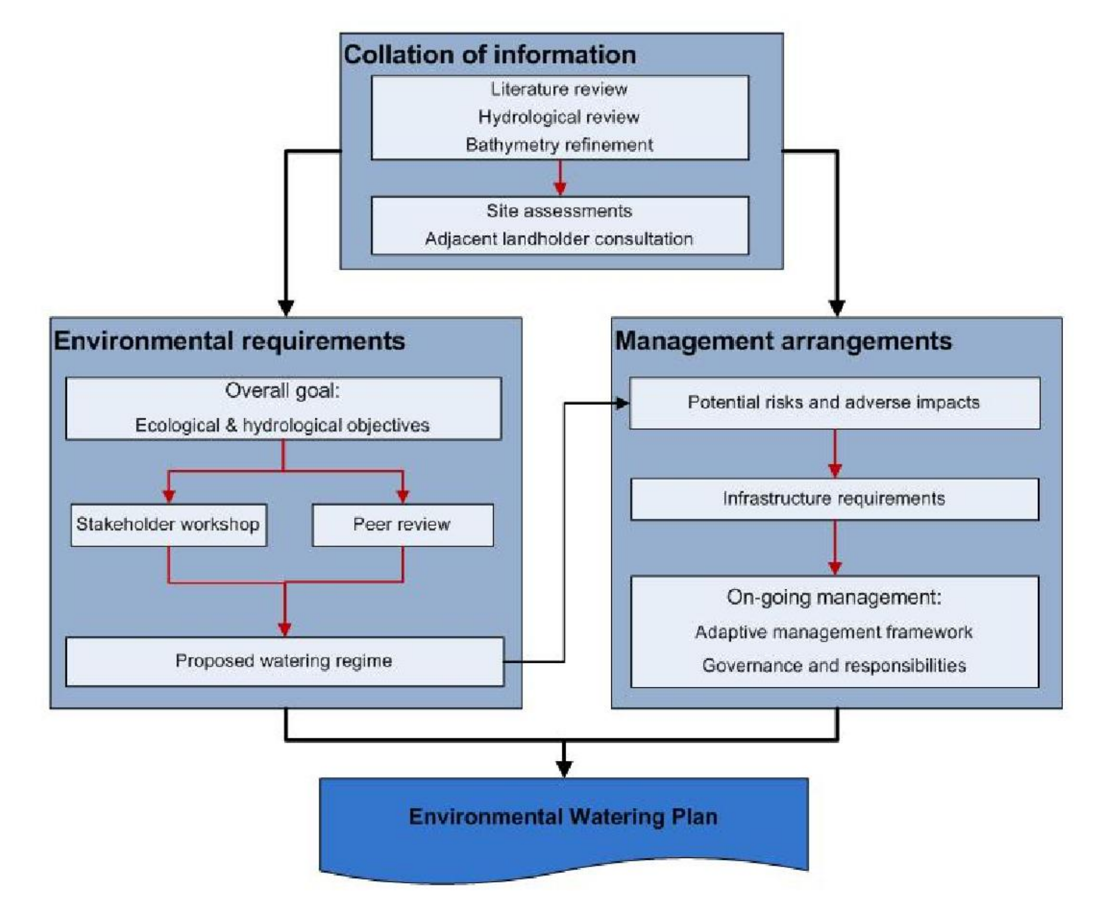

Figure 1: EWP development process

1.4.1 Consultation and engagement

To assist in collating information for the Johnson Swamp Environmental Watering Plan a targeted community and agency engagement process was undertaken. Key groups consulted were the 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 the CMAs, G-MW, DPI, NVIRP and DSE (Appendix A). A contents template for the EWPs was developed and approved by the TAC in December 2008.

A workshop was held on 19 March 2009 with key stakeholders and relevant experts (Appendix A) to refine the proposed ecological objectives and watering requirements for Johnson Swamp. In addition, key components of the draft plan were presented and reviewed by an independent expert panel comprising of Brett Lane (Brett Lane & Associates), Terry Hillman (Hillman *et al*.) and Peter Alexander (Hydro Environmental) on 6 April 2009.

Consultation was also undertaken with adjoining landholders who have had a long association with the wetland and proven interest in maintaining its environmental value. Other community and agency people were directly engaged to provide technical and historic information including G-MW water bailiffs, duck hunters (Field & Game Association), bird observers and field naturalists. A summary of the information sourced from this process is provided in Appendix B.

2. Johnson Swamp

Johnson Swamp is a 340 ha[1] wetland situated approximately 15 km south-east of Kerang (Figure 2). It is located in the Pyramid Creek sub-catchment of the Loddon river basin. It is a wetland of international and national significance being part of the Kerang Wetlands Ramsar site and listed in the Directory of Important Wetlands in Australia. It has the potential to support a significant diversity and abundance of invertebrates, waterbirds and flora species, and to act as a drought refuge.

Prior to European settlement, Johnson Swamp was an intermittent shallow freshwater marsh dominated by Black Box. A change to the hydrology of the area, most notably the development of the Torrumbarry Irrigation System in the 1920s and changing land use, has resulted in a shift in classification to that of a deep freshwater marsh (DCFL 1989, DSE 2009b). Deep freshwater marshes remain flooded for most of the year but may dry out occasionally.

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

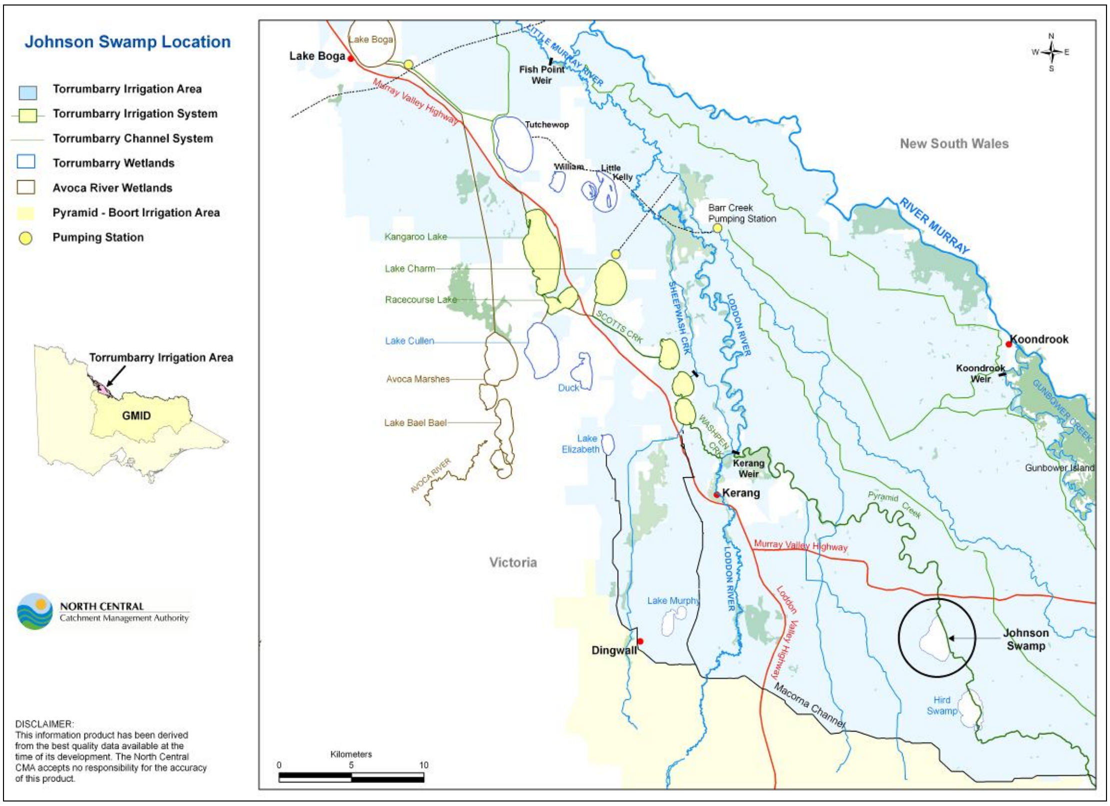

Figure 2: Location of Johnson Swamp

2.1 Catchment setting

Johnson Swamp is located within the Pyramid Creek sub-catchment in the Victorian Riverina and Murray Fans (eastern edge) bioregions. The local catchment area (300 ha) is low-lying and prone to flooding which has deposited rich, relatively impermeable sediments (SKM 2001). The surrounding land use is agricultural, consisting primarily of irrigated cropping and pasture.

Rainfall in the Kerang region averages 377mm/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 temperatures rarely falling below zero (BOM 2009).

[1] Johnson Swamp has previously been recorded as having an area of 411 hectares. Review of bathymetric information updated the full supply level for the wetland to 340 hectares. Inundating the wetland to 411 hectares would inundate the surrounding agricultural land (Archard's Irrigation, 2009).

Johnson Swamp is traversed by Pyramid Creek which separates it into Johnson Swamp East and Johnson Swamp West. The EWP addresses Johnson Swamp West only, which receives G-MW channel outfall water. Johnson Swamp is directly connected to the Torrumbarry Irrigation System via the 4/7/2 channel (Figure 3) and has historically received significant channel outfalls. Following the planned modernisation of irrigation infrastructure by the NVIRP, the efficiency of the irrigation delivery system will improve, reducing the volumes of outfall water received by the wetland by approximately 85%.

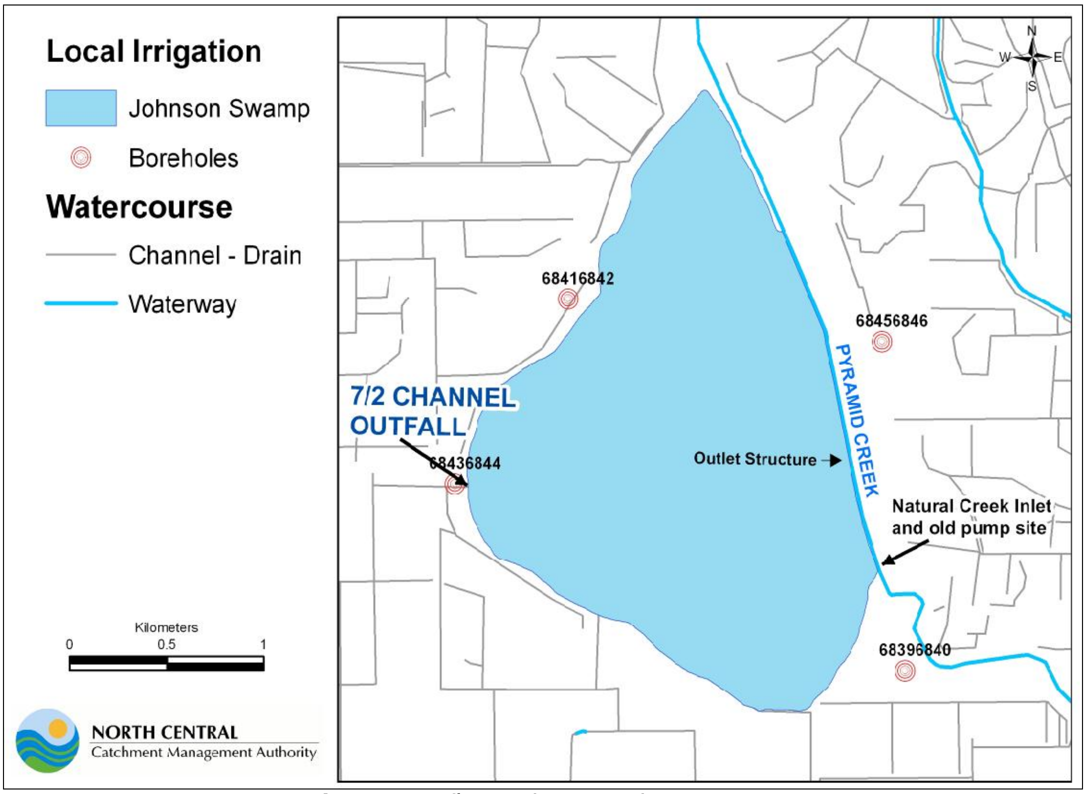

Figure 3: Inflow points at Johnson Swamp

2.2 Land status and management

Johnson 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 specifically managed for the conservation of fish and wildlife and for public recreation (VEAC 2008).

In 2009, the Victorian government endorsed (with amendments) the Victorian Environment Assessment Council (VEAC) recommendations for public land management. Johnson Swamp will form part of Johnson Swamp Wildlife Area under the "natural features reserves" classification. These reserves will be managed to protect natural values, conserve flora and fauna and cultural heritage, while permitting their use for recreational and educational purposes including hunting (VEAC 2008 and DSE 2009c).

2.3 Legislative and policy framework

2.3.1 International agreements

Ramsar Convention on Wetlands

The Ramsar Convention, to which Australia is a signatory, provides a framework for national action and international cooperation for the conservation and wise use of wetlands and their resources. Johnson Swamp forms a component of the Kerang Wetlands Ramsar site, listed as a wetland of international importance in 1982 (DSE 2004). The site occupies an area of 9,419 ha and consists of 22 wetlands (DSE 2004). Ramsar wetlands in Australia are protected by the federal *Environment Protection and Biodiversity Conservation Act (EPBC) 1999* (Section 2.3.2).

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

- JAMBA (Japan–Australia Migratory Bird Agreement)

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

Johnson 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, Johnson Swamp is required to be protected and conserved in accordance with these international agreements (DEWHA 2009).

2.3.2 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.

Johnson Swamp is known to support a number of species listed under the *EPBC Act* (Tables 1 and 2). Actions that may significantly impact any of these matters of national environmental significance (including the site itself) 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 1999*.

2.3.3 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. Johnson Swamp is known to support a number of species both protected and listed under the *FFG Act* (Tables 1 and 3). Disturbance or collection of any of these threatened species will require a permit from the DSE.

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

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

Water Act 1989
The *Water Act 1989* is the key piece of legislation that governs the way water entitlements are issued and allocated in Victoria. The Act also identifies water that is to be kept for the environment under the Environmental Water Reserve. The Act provides a framework for defining and managing Victoria's water resources.

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

Other- Threatened Species Advisory Lists
Threatened species advisory lists for Victoria are maintained by the DSE and are based on technical information and advice obtained from a range of experts which are reviewed every one to two years. These advisory lists are not the same as the Threatened List established under the Victorian 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.

3. Johnson Swamp values

Johnson Swamp supports a range of environmental, cultural heritage, recreation and 'water operational management' values. These are described in the following sections.

3.1 Environmental values

Johnson Swamp is a relatively large open freshwater wetland that is recognised as having very high conservation value particularly pertaining to its bird habitat (SKM 2001). This Lignum/Black Box wetland has the capacity to support a high diversity and abundance of waterbird species and provides an important drought refuge during its wetting cycle. Nationally, it is considered to be a good example of a wetland type in Australia that is rare and plays an integral part in the ecological or hydrological functioning of a major wetland complex (ANCA 1996).

3.1.1 Fauna

The conservation significance of Johnson Swamp is primarily due to its high carrying capacity, species diversity and level of breeding of waterbirds (Lugg, Heron, Fleming and O'Donnell, 1989). The wetland supports species protected by international agreements (JAMBA/CAMBA/ROKAMBA), and national (*EPBC Act 1999)* and state (*FFG Act 1998*) legislation. It is listed as internationally significant in part because it regularly supports large numbers of waterfowl, Black Duck and White Ibis (DSE 2006a).

Forty-two bird species have been recorded at Johnson Swamp with records indicating that 16 are significant, threatened or vulnerable, including the Australian Painted Snipe (*Rostratula australis*) and the Australasian Bittern (*Botaurus poiciloptilus*) (Table 1 and Appendix D). One vulnerable frog species the Grolwing Grass Frog (*Litoria raniformis*) has also been recorded at Johnson Swamp.

Table 1: Significant species recorded, or considered likely to occur, in Johnson Swamp

Common name	Scientific name	International agreements	EPBC listing	FFG listing	DSE listing
Fauna					
Australasian Bittern[1]	*Botaurus poiciloptilus*			L	EN
Australasian Shoveler	*Anas rhynchotis*				VU
Australian Little Bittern[1]	*Ixobrychus minutus dubius*			L	EN
Australian Painted Snipe	*Rostratula australis*	C	VU	L	CR
Brown Treecreeper (s-e spp.)[1]	*Climacteris picumnus victoriae*				NT
Eastern Great Egret[1]	*Ardea modesta*	J / C			
Freckled Duck	*Stictonetta naevosa*			L	EN
Great Egret	*Ardea alba*	J / C		L	VU
Growling Grass Frog	*Litoria raniformis*		VU	L	CR
Hardhead	*Aythya australis*				VU
Intermediate Egret	*Ardea intermedia*			L	CR
Musk Duck	*Biziura lobata*				VU
Pied Cormorant[1]	*Phalacrocorax varius*				NT
Royal Spoonbill	*Platalea regia*				VU
Sharp-tailed Sandpiper	*Calidris acuminata*	J / C / R / B			
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
- DSE listing: CR – Critically Endangered, EN – Endangered, VU – Vulnerable, NT – Near Threatened

Note 1: (DSE 2009d) – considered likely to occur

3.1.2 Vegetation communities

Prior to European settlement, according to pre-1750 Ecological Vegetation Class (EVC) mapping, Johnson Swamp was a lignum swampy woodland surrounded by riverine chenopod woodland vegetation (DSE 2009e). The current EVC mapping (DSE 2009f) for Johnson Swamp indicates that the 1750 EVCs are still present. However, recent monitoring has shown that these EVCs are severely diminished (Davies, Davies and Downs 2005) (Table 2).

Table 2: Johnson Swamp EVC mapping

EVC No.	EVC	Bioregional Conservation Status	
		Victorian Riverina	Murray Fans
103	Riverine chenopod woodland	Vulnerable	Endangered
132	Plains grassland	Endangered	Endangered
823	Lignum swampy woodland	Vulnerable	Vulnerable
829	Chenopod grassland	Endangered	Endangered

Six significant flora species have been recorded at Johnson Swamp including Cane Grass (*Eragrostis australiasica*), Black roly-poly (*Sclerolaena muricata*) and Eel Grass (*Vallisneria spiralis*) (Table 3 and Appendix D).

Table 3: Significant flora species recorded at Johnson Swamp

Common name	*Scientific name*	EPBC listing	FFG listing	DSE listing
Black roly-poly	*Sclerolaena muricata var. muricata*			DD
Cane grass	*Eragrostis australasica*			VU
Drooping Wattle	*Acacia difformis*		P	
Eel Grass	*Vallisneria spiralis*		L	
Rough Wattle	*Acacia aspera*		P	
Thin-leaf Wattle	*Acacia aculeatissima*		P	

Conservation Status:
- FFG listing: L – Listed as threatened, P - Protected
- DSE listing: VU – Vulnerable, DD – Data Deficient

The environmental values of Johnson Swamp have been impacted by the colonisation of Common Reed, Cumbungi and exotic weed species such as Wild Lettuce (*Lactuca serriola*). Chenopods have colonised areas that would originally have been occupied by lignum, reeds and rushes indicating a move to a drier wetting regime. Appendix E illustrates the generic vegetation composition of Johnson Swamp surveyed in March 2009.

3.1.3 Representativeness and distinctiveness

Johnson Swamp is representative of the most depleted wetland category within Victoria, the deep freshwater marsh. It is estimated that the area of deep freshwater marshes across Victoria has decreased by approximately 70% since European settlement (DNRE 1997). Table 4 illustrates the area and proportion of deep freshwater marshes across various defined landscapes.

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

	North Central region	GMID	Victorian Riverina	Murray Fans	Victoria
Deep freshwater marshes (ha)	4,880[1]	7,297[1]	6,364[1]	1,831[1]	54,887[1]
Johnson Swamp (340ha)	7%	5%	5%	19%	<1%

Note 1: Areas calculated (DSE 2009g)

Johnson Swamp occupies 340 hectares which is considered large in comparison to other wetlands within the North Central region. Only 6% of wetlands within the region are greater than 100 ha in size (NCCMA 2005).

Johnson Swamp is distinctive because it supports the following characteristics:

- Large numbers of Straw-necked Ibis, Australian White Ibis and Black Duck (ANCA 1996).
- Threatened flora and fauna species (Section 3.1).
- A more diverse invertebrate fauna assemblage than any of the Kerang Lakes wetlands (Fleming 1990).

3.1.4 Ecological processes

Wetlands are transitional zones between terrestrial and aquatic systems and support a myriad of ecological processes that are influenced by the wetting and drying cycles. These processes include physical processes such as stratification, sedimentation and erosion, ecological processes such as energy dynamics and nutrient cycling, and biological processes such as the movement, reproduction and growth of species (Boulton and Brock 1999).

A short description of the ecological processes that Johnson Swamp is likely to support is provided below.

Flooding – arrival of water
Upon flooding, the soil releases nutrients which promote biological growth, stimulating phytoplankton and zooplankton production (macroinvertebrates). Aquatic plants (submerged and emergent) respond by germinating from resident seedbank and propagules. Other plants respond with flushes of new growth. The newly inundated areas attract frogs that spawn and turtles that lay eggs, in and around the wetland.

Wetland inundation period
At this stage, waterbirds arrive attracted by the abundant food sources in the littoral and open water zones. The wetland provides an important drought refuge for wildlife, transforming into a highly productive system capturing energy and providing food and habitat for fauna.

Drying phase
As the wetland dries, waterbirds fledge and depart. Aquatic plants complete their life cycle, die off and release nutrients, which are captured in the wetland bed and sediments. Bacterial activity within the bed switches from anaerobic to aerobic as the wetland bed becomes exposed to the air. Aquatic plants set seed and invertebrates lay eggs. Regeneration of flood dependant species occurs, such as Lignum and Black Box.

3.2 Cultural heritage

The Kerang Lakes area is a significant archaeologically important area in Victoria. Thirteen Aboriginal archaeological sites have been recorded around the margins of Johnson Swamp and include four isolated artefacts, seven mounds, and two scar trees (AAV 2000 in SKM 2001).

3.3 Recreation

Johnson Swamp is as a valuable wetland for recreation in the Kerang Lakes area. It supports the following recreational activities:

- Picnicking
- Hunting
- Bird watching and other nature based activities
- Walking (Heron and Nieuwland, 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 aspects of a wetland, which in turn affects the type of values the wetland supports (DSE 2005). 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 2005). Duration, frequency and seasonality (timing) are the main components of the hydrologic regime for wetlands and rivers.

Johnson Swamp is located within the Pyramid Creek sub-catchment in the Loddon River basin. The wetland's natural water supply originates from overflows in Pyramid Creek. Pre-European settlement, Johnson Swamp received intermittent flooding originating from a large catchment area to the south and southeast. Water from Bendigo Creek flowed into Kow Swamp which would have overflowed during extended wet periods, into Pyramid Creek (Rob O'Brien, DPI, pers. comm. 2009).

The natural hydrological cycle of Johnson Swamp would have consisted of flooding in winter and spring with drawdown due to evaporation occurring over the summer months (SKM 2001).

4.1 Water management

Historically, Johnson Swamp was used as a freshwater irrigation storage which enabled flushing of water through the wetland and increased its permanency. Dredging of Pyramid Creek in 1969 further altered the flow regime, disconnecting the wetland from its natural catchment. A levee bank (78.4m AHD) located along the banks of Pyramid Creek has separated the wetland further, except during major floods.

Water was subsequently delivered by pump from Pyramid Creek (up to the 1980s) and later from the irrigation channel 4/7/2 (Figure 3), primarily to maintain waterfowl breeding for duck hunting (SKM 1996).

Johnson Swamp has historically received (prior to 1998) significant outfalls from the 4/7/2 channel system from rainfall rejection events occurring after heavy rains, and surplus flows. Since the 1990s due to system upgrades and increased efficiencies, outfall water to Johnson Swamp has been reduced (Figure 4).

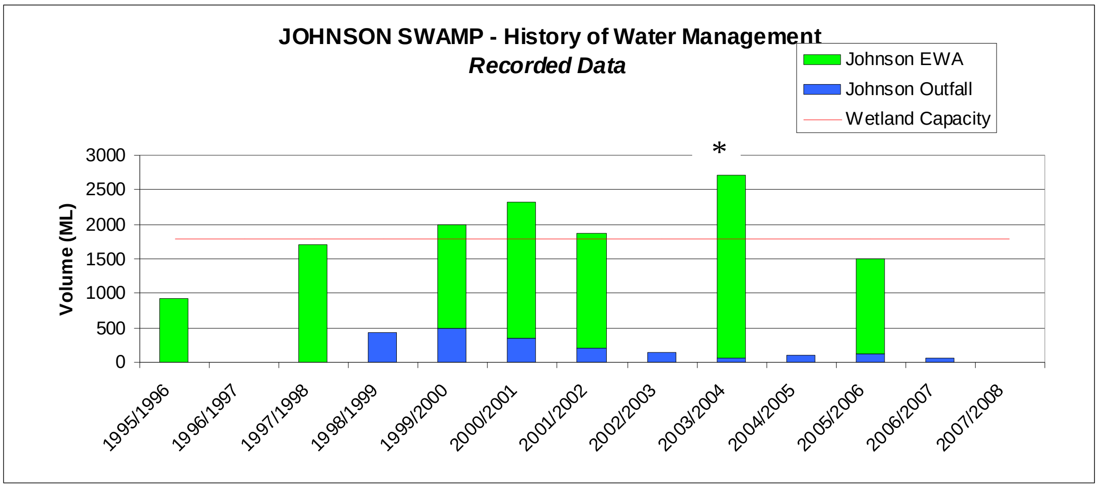

Figure 4: Johnson Swamp watering regime (1995-2008)

Note: Outfalls recorded by G-MW from 1998 only. * Includes top-up volumes to counter evaporation losses.

Over the past decade, Johnson Swamp has experienced more frequent drying phases due to the drought, increased efficiencies in the irrigation system and the lack of environmental water.

Part of the Murray Flora and Fauna Bulk Entitlement (27,600ML) has frequently been utilised for Johnson Swamp to provide a drought refuge for waterbirds (DSE 2006). The cycle of wetting and drying and relative water sources is shown in Table 5. Plates 1 and 2 illustrate the different phases.

Table 5: Johnson Swamp wetting/drying calendar **(Source: DSE, 2008a)**

Year	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
Wetting / drying cycle[1]	w	d	w	w	w	w	w	w	w	d	w	d	w	d	d	d
Water Source[2]	U		E	u	E	TIS	E / TIS	E / TIS	E / TIS		E / TIS		E / TIS			

Note 1: w – water present, d – wetland dry
Note 2: U – unknown, E – environmental water allocation, TIS – Torrumbarry Irrigation System

Plate 1: Wet Phase (date unknown)

Plate 2: Dry Phase (March 2009)

4.1.1 Recorded outfalls and NVIRP

Outfall data for Johnson Swamp has been recorded by G-MW since 1998 (Figure 4). Records indicate that outfall volumes have decreased significantly between 1998 (424 ML) and 2008 (0 ML). Anecdotal information as noted above, suggests that historically larger outfall volumes provided a wetter water regime.

The baseline water year, 2004-2005, has been selected to quantify the savings as part of water savings projects. 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 2008c). This baseline year will also be used to guide the quantification of mitigation water required for wetlands (discussed in Section 5), taking into account the average annual patterns of availability.

Johnson Swamp received a total of 92.5 ML of outfall water in 2004-2005. The timing of the outfalls, over the irrigation period of September to May, is shown in Figure 5.

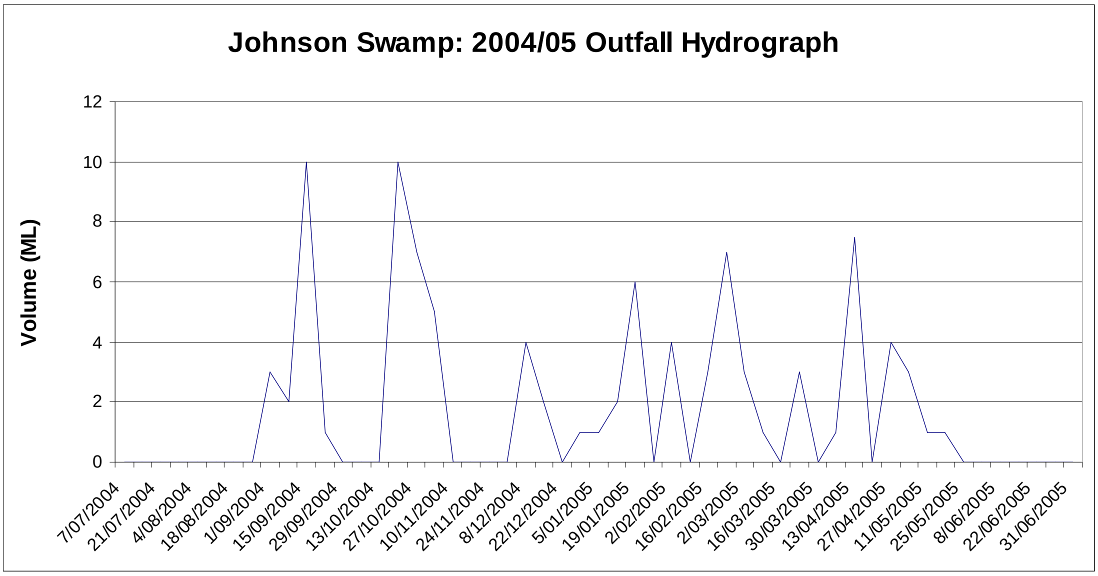

Figure 5: Johnson Swamp outfall hydrograph

Following the planned modernisation of irrigation infrastructure by NVIRP, the efficiency of the irrigation delivery system will improve by 85%, thus reducing the volumes of outfall water received by the wetland. Using the 2004-2005 baseline year for Johnson Swamp, this would reduce the volume to approximately 15 ML/year.

4.2 Operational uses

Johnson Swamp is a terminal system filled by rainfall, channel outfalls from the G-MW 4/7/2 channel (either as operational outfall or environmental water) and surface drainage water. No operational plans or procedures exist for the G-MW management of the wetland.

Johnson Swamp is used as an operational outfall, although the onset of drought initiatives and efficiency programs has considerably reduced outfall volumes (Section 4). There are no existing diversion licences from Johnson Swamp.

4.2.1 Flood mitigation

The natural flooding of Johnson Swamp from Pyramid Creek is prevented by levees and the dredging of the creek.

The wetland is not actively managed for the distribution or storage of floodwater (Rural Water Commission 1990). However, there is potential to divert floodwater and surplus flows via the 4/7/2 G-MW channel outfall.

4.2.2 Drainage

Johnson Swamp has a local catchment area of approximately 300 ha. Local runoff occurs in 'wet' years from the adjoining agricultural land. On average, runoff into the wetland is not considered to be significant, as the volumes are relatively small.

Local catchment runoff could impact on the environmental values of Johnson Swamp as intensive farming practices are located in the vicinity of the wetland.

4.2.3 Water quality contributions

Johnson Swamp is a terminal system with no outflows. The majority of water is lost through evaporation.

4.3 Surface water/groundwater interactions

Previous recommendations for management of Johnson Swamp (SKM 1996 and 2001) were based on managing the risk of groundwater (with a salinity of 30-40,000EC) intrusion. The Department of Primary Industries has monitored surface water at Johnson Swamp since 1990 and the groundwater since 1991, on a monthly basis. Bore locations are shown, together with irrigation infrastructure in Figure 3 (Section 2.1).

Assessment of the hydrograph of water table depths suggests that there is groundwater flow from the west of the wetland to the east (higher watertable elevations in Bores 6842 and 6844). This is consistent with the 7/2 channel outfall on the west side and the Pyramid Creek drain on the east side (Reid and O'Brien 2009).

Groundwater levels have been on a downward trend, with the most marked decline occurring since 2006. The recent declines have varied between 1 and 2 metres, lowering the watertable to between about 75.8 and 76.2 m AHD (July 2008), thus creating a flat watertable surface that is reflective of the regional aquifer system.

Recorded watertable depths in July 2008 were between 2.5 and 3.5 metres from the ground surface. The hydrograph (Figure 6) record shows that most years have recorded seasonal rising fluctuations (sometimes more than one in a year) regardless of whether the wetland has been inundated, indicating additional influences from rainfall and possibly irrigation. The record shows fairly dynamic groundwater behaviour and a noticeable decline since 2006 with all levels being between about 75.8 and 76.2 m AHD as at July 2008.

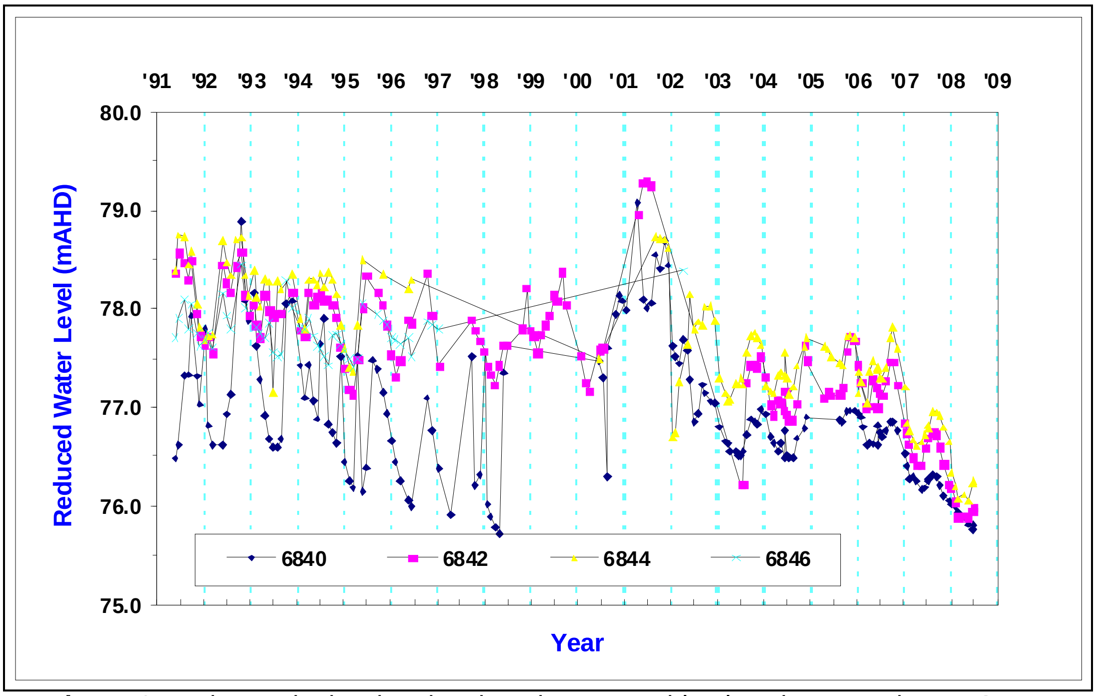

Figure 6: Hydrograph showing the changing watertable elevations at Johnson Swamp

The current low groundwater levels and similarity in watertable elevations indicate the following:

- A low risk of salinisation and favourable conditions for periodic wetland wetting to maintain/improve environmental values.
- With the possibility of generally lower surrounding watertables in the future combined with lower volumes of applied irrigation water, this data adds further weight to the benefits and safety of occasional inundation of wetland.

It is expected that subsequent periodic environmental watering of Johnson Swamp will have some temporary impact on the watertable locally and will assist in moving salt away from the lake without causing significant risk to adjacent areas, provided the watering is not too frequent (e.g. once every two or three years).

From the information sourced, it is concluded that if Johnson Swamp is left in a dry (or predominantly dry) state, it may accumulate and retain relatively high salt levels without sufficient water to flush these into the groundwater system, and hence may impact on plant species composition/health. Nevertheless, assuming continued dry climate conditions, the risk of significant salinity degradation in this scenario is still anticipated to be low, due to low surrounding watertable levels. Further, it is understood that the Pyramid Creek drain running along the eastern side has been recently deepened significantly and this will most likely act to provide watertable relief near the wetland should wetter conditions return.

(Source: Reid and O'Brien 2009)

4.4 Surface water balance

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

4.4.1 Maximum volumes required

The maximum volume required to fill Johnson Swamp has been calculated using the following equation:

Volume required (ML) =
Wetland capacity + infiltration + evaporation (filling) + evaporation (full wetland)

Note: the volume does not include inflows from rainfall and surface run-off (refer to below).

Wetland capacity: volume required to fill the wetland to the targeted supply level, i.e. Johnson Swamp filled to approximately one metre depth equates to 1783 ML (Archard's Irrigation 2009).

Infiltration: volume required to fill the underlying soil profile, calculation of this volume has been adapted from measurements undertaken by G-MW, (G-MW 2008b):

- 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)

Evaporation (filling): the volume of water lost while filling the wetland is dependant on the time it takes to fill. Evaporation rates of 4mm/day during spring have been used for this calculation as it coincides with the timing to fill the wetland. This has been calculated as follows:

- Evaporation while filling (ML) = (0.5 x area of wetland (ha) x days to fill)/100 (G-MW 2008).

Evaporation (full wetland): evaporation from the lake surface is dependent on the area inundated - surface area of 340 hectares (Archard's Irrigation 2009).

4.4.2 Minimum volumes required

The minimum volume required to fill Johnson Swamp has been calculated using the following equation.

Volume required (ML) =
Wetland capacity – total inflows (rainfall and surface run-off) + total outflows (infiltration and evaporation

Note: Surface drainage and groundwater inflows have not been quantified as the data was not available.

Wetland capacity: as above.

Total inflows: this includes rainfall directly falling onto the wetland and surface run-off.

- Rainfall: Long term average rainfall data (BOM 2009)
- 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 catchment area of 300 hectares were used.

Total outflows: this includes infiltration and evaporation losses as described above.

5. Management objectives

Once its use as an irrigation storage ceased, Johnson Swamp was managed to maintain the resting, nesting and feeding habitat for large numbers of waterbirds. Table 6 outlines the management recommendations for the wetland from previous Johnson Swamp reports.

Table 6: Previous management recommendations

Source	Wetland Type	Objectives	Dur	Timing	Freq[1]	Quality (EC)
Lugg et al., 1989	Semi-permanent wetland	• Waterbirds- resting, feeding, breeding	8-9 months	Winter/ spring	1/1 2/3	In wetland <1500
KLAWG, 1992	Semi-permanent wetland	• Waterbirds- resting, feeding, breeding • Recreation	n/a	n/a	3/4	In wetland <1500
SKM, 1996	n/a	• Manage rising salinity levels and enhance environmental values	<12 months	Aug-Oct	2/3	<2,000 1-2 yr <1,500 3-5 yr
Kelly, 1999	n/a	n/a	<12 months	Aug- Dec		
PV, 2000	Wildlife Reserve	• Breeding habitat for Freckled Duck • Control of *Typha* and *Phragmites* • Recreation • Groundwater intrusion • Water quality	n/a	n/a	n/a	n/a
SKM, 2001	n/a	• Ecological and biodiversity values • Diversity of habitats • Typha and *Phragmites* control • Groundwater intrusion	12 months[2]	Aug-Dec @ 2cm/d	1/2	Fill with <600
DEWHA, 2008	Deep freshwater marsh	• Breeding of water birds • Drought Refuge • Lignum and Black Box habitat	8-9 months	Spring	1/3 (average)	Fill with <500 In wetland <1500
Heron and Joyce, 2008	Deep freshwater marsh	• Waterfowl (incl. Hardhead, Blue-billed Duck, Freckled Duck, Musk Duck) • Migratory birds (JAMBA/CAMBA species) • Waders (Dotterel, Stint)	10 months	Spring	Between 1/2 1/5	n/a

Note 1: Frequency of filling
Note 2: SKM 2001 recommendations are based primarily on managing groundwater intrusion and therefore keeping the wetland full if groundwater levels are high.

5.1 Management goal

The overall goal proposed for Johnson Swamp is derived from a variety of sources, including historic management goals, local expertise and knowledge and current climate predictions, and has been appraised by various experts and stakeholders (wetland workshop, Appendix A Table A2). It considers the values the wetland supports and the potential risk factors that need to be managed (e.g. spread of Common Reed).

Johnson Swamp goal
To provide a watering regime that supports a mosaic of plant communities including Lignum/Black Box and open water which provides key habitat for a diverse range of waterbirds

The goal for Johnson Swamp recommends a slightly drier operating regime than previously recommended. The process for determining the goal involved assessing the values the wetland has historically supported and the likely values it could support into the future considering climate change. It was determined that the goal needed to be achievable and that the watering regime needed to support the values in the long-term (i.e. ensuring viability of species and habitats into the future). The primary objectives identified for Johnson Swamp are presented in the following section. These guided and effectively determined the ultimate goal and watering regime for Johnson Swamp.

5.2 Ecological and hydrological objectives

Ecological objectives for Johnson Swamp represent the desired ecological outcomes for the wetland and were developed to determine the optimal watering regime for the swamp to protect its high environmental values.

Values (i.e. communities, species, processes and habitat dependant on flow) were identified from species records and anecdotal information. Water-dependant species and communities with recognised conservation significance were given highest priority in addition to others that are indicative of integrated ecosystem function i.e. important for habitat quality.

Objectives were identified for each of the values in terms of the desired condition of species and/or biota (biodiversity objectives), biological processes (process objectives) and physical conditions (habitat objectives). The objectives were expressed as one of four main targets, 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 objectives for each of the values were identified. These 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. colonial waterbirds require certain timing, duration and frequency of flooding to successfully breed and maintain their population. Requirements for the three components of flow were identified and described for all of the ecological values. These essentially provide the hydrological objectives required to enable achievement of the ecological objectives.

(Source: Campbell, Cooling & Hogan 2005.)

The ecological and hydrological objectives for Johnson Swamp were presented at the NVIRP Environmental Watering Plan Workshop held in March 2009 with representatives from agency stakeholders and experts. In addition, they were presented to the expert panel on 30 March 2009. Any amendments or alterations were incorporated and the final objectives are presented in Table 7.

Table 7: Johnson Swamp Objectives

Ecological objective	Justification	Hydrological objective	Limiting factors
1. Habitat objectives			
1.1 Restore open water/submerged aquatic assemblage for the deeper/lower sections of the swamp.	Open water and mudflat habitat (feeding and roosting) for waterbirds (Australian Painted Snipe, Musk Duck, Royal Spoonbill, Sharp-tailed Sandpiper and Whiskered Tern).	Develop an open water submerged aquatic assemblage by providing a 2 in 5yr inundation to at least 50cm deep.	• Water delivery (outfall location compared to bathymetry) • Turbidity • Potential for Common Reed and Cumbungi spread • *Persicaria* (Knotweed) monoculture (shallow water could lead to a monoculture of less productive species) • Filamentous algae
1.2 Restore and maintain health of Lignum vegetation.	Habitat for waterbirds, for example: • Australasian Bittern • Freckled Duck (nesting and breeding) • Whiskered Tern (nesting and breeding) • Ibis (although not listed, historically breed at Johnson Swamp)	Re-establish a scattered Lignum community by providing short duration flooding for 2-3 months, for 1 in 3 to 1in 7 years.	• Potential for Phragmites and Cumbungi spread • Fire

Ecological objective	Justification	Hydrological objective	Limiting factors
1.3 Restore health and expand distribution of Black Box community • Maintain health of existing trees • Provide opportunities for regeneration	Black Box trees provide hollows, fallen branches and reset the vegetation mix. Also provides nesting and roost for birds: • Brown Treecreeper (hollows are essential for nesting) • Eastern Great Egret (roosting and nesting) • Intermediate Egret (roosting and nesting) • Pied Cormorant (nesting) • Royal Spoonbill (nesting) • White-bellied sea-eagle (perching and nesting)	Re-establish Black Box by providing periodic short duration flooding for 2-3 months, for 1 in 3 to 1in 7 years. • Timing: Winter/ early Spring (critical to salinity management)	• Viability of existing seedbank and regeneration capacity of existing trees • Soil salinity (unknown) • Fire
1.4 Reduce the dominance of Phragmites *spp*.(P) and Cumbungi (C)	Re-create a more diverse and robust assemblage of native plants, although supports: • Australasian Bittern (C&P) • Australasian Shoveler (C) • Brown Treecreeper (C) • Eastern Great Egret (C) • Hardhead (C) • Intermediate Egret (C&P) • Musk Duck (C) • Whiskered Tern (C&P) • Growling Grass Frog	Growth limited by extended dry conditions. The preferred water regime for Black Box /Lignum will inhibit Phragmites *spp*. / Cumbungi growth.	• Requires active management for effective control
2. Species/Community objectives			
2.1 Restore breeding of waterbirds[1] • White Ibis[2], Great-crested Grebe • Black Swan, Australian Shelduck, Pacific Black Duck and Freckled Duck	Wetting and drying cycle is vital for food generation in the wetland bed (this food provides ideal conditions for breeding).	Re-establish successful breeding events by filling in Spring and keep wet for 7-10 months.	• Lag time between wetland watering and bird breeding – requires monitoring to ensure appropriate duration • Reliable supply of food/nesting sites (for breeding, may also require rainfall stimulus) • Phragmites *spp*. and Cumbungi monoculture (2005/06 watering event was unproductive) • Hunting • Water quality • Pest plants and animals • Monitoring is required
2.2 Restore feeding opportunities (food source) for water birds	Linked with habitat objectives – wetland and dryland flora, shallow water, mudflats and waters edge. Also linked to community/species objective 2.3	Re-establish waterbird food source- inundating open water submerged aquatic assemblage and littoral zone by providing a 2 in 5yr inundation to at least 50cm deep (Hydrological Objective 1.1). Invertebrates conditions variable; water quality important	
2.3 Restore diversity and abundance of invertebrate community	Linked with fauna objective 2.2 and habitat objective 1.1 above.		
2.4 Restore breeding opportunities for frogs (in particular the Growling Grass Frog)	Physical habitat and previous recordings at site	• Tadpoles require algae and slow flowing water • Late Winter/Spring/Summer • 4 months duration • 6-9/10 years	• TBD
2.5 Maintain/Restore Cane Grass	Provides habitat for Brolga (v) and Egrets (v), Hardhead (v), Whistling Kite, Swamp Harrier, Black Swan.	Species present in wetlands with inundation of 4-6 months to approximately 1 m deep.	• TBD
3. Process objectives			
3.1 Restore connectivity between river and floodplain and between floodplain components	Invertebrate source Nutrient and carbon cycling Species population sources	Variable	• May not be possible to link with a river or floodplain. • Inflow may be only future source of water.

Note 1: Recorded breeding events by waterbird species at Johnson Swamp (DSE, 2006)
Note 2: Provided from anecdotal evidence

5.3 Proposed water regime

Based on the defined ecological and hydrological objectives for Johnson Swamp, a wetland watering regime has been derived and is outlined below. A schematic is provided to illustrate the various components of the wetland (e.g. Black Box/Lignum community and submerged aquatic zone) that are being targeted by the watering regime (Figure 7).

Timing: Winter/Spring

Frequency of wetting: Minimum: one in seven years
Optimum: one in five years
Maximum: one in three years

Duration: Variable (habitat dependant), two to three months (Lignum/Black Box) to two years (for open water area)

Extent and depth: dependant on objective targeted

- Open water assemblage 30cm to 70cm deep for submerged aquatics
- Lignum/Black Box entire swamp for two to three months

Variability: High (objectives will shift depending on wetting/drying cycles and waterbird breeding events)

Overall wetland watering regime:
Fill wetland to capacity one in five years and ensure inundation period of Lignum/Black Box areas does not exceed two to three months (consider release back to Pyramid Creek from outlet). Dependent on evaporation and seepage, top-up/provide smaller volume in the following year to maintain inundation of the open water assemblage (to at least 30cm). Completely dry the following year

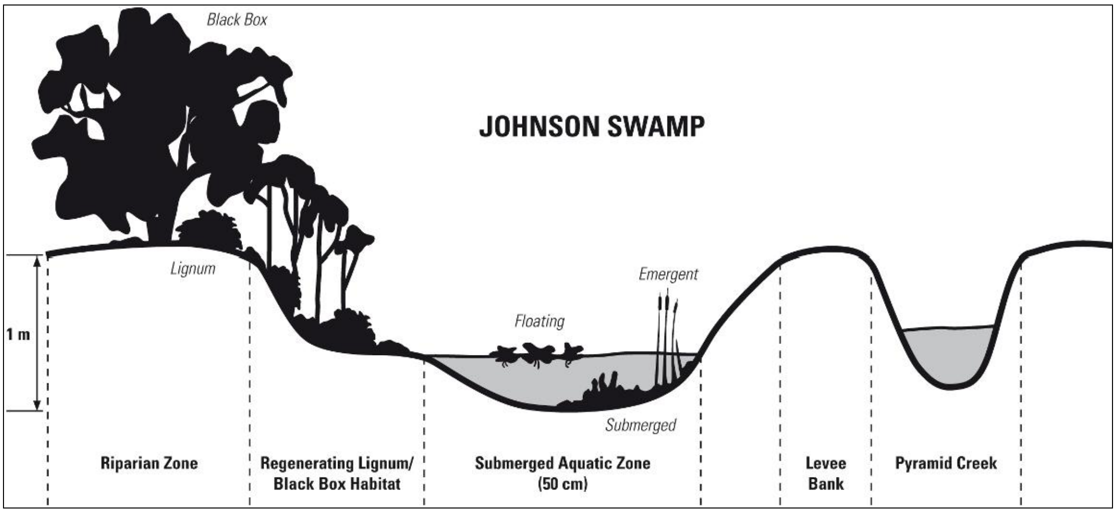

Figure 7: Schematic of wetland areas to be targeted (not to scale)

The volumes of water required to provide the recommended watering regime for Johnson swamp are presented in Table 8. These volumes incorporate evaporation and seepage rates from the surface water balance calculations (Appendix F).

In year one, Johnson Swamp is filled to capacity to inundate the Black Box/Lignum area. Evaporation (2852 ML/year) will reduce the water level to the lower parts of the wetland (submerged aquatic assemblage area). This area is maintained to a depth of 30cm (113 ha) for up to 18 months.

Table 8: Volumes required

Year	Area (ha)	Capacity (air space)	Infiltration	Evaporation (filling)	Evaporation (inundation period)[1]	Total Volume Required
1	340	1783	255	139	n/a	2177 ML
1[2]	113	153	N/A	3	1322	828 ML[3]
2[2]	113	153	N/A	3	1220	1067 ML
3	DRY PHASE					0 ML
4	DRY PHASE					0 ML
5	DRY PHASE					0 ML

Note 1: in year one, evaporation (during the inundation period) is not accounted for in the total volume required – although evaporation will occur the ecological objectives are targeting Lignum/Black Box which requires two to three months inundation. Evaporation is required to drawdown water levels from these areas.
Note 2: targeting only the open water submerged aquatic assemblage area.
Note 3: after the initial 3 months of inundation 494 ML still remains in the wetland.

Other inflows (i.e. surface run-off and rainfall) are not included in Table 8. Surface water inflows to Johnson Swamp and rainfall will vary considerably from year to year depending on seasonal conditions. Estimates have been calculated for inflows based on the annual average rainfall (Appendix F). These are 652 ML/year (rainfall directly falling on wetland) and 61 ML/year (surface run-off). Therefore, in an average year (accounting for all significant inflows and losses) the total volume required to fill Johnson Swamp and maintain the open water assemblage area for 12 months, would be reduced to 2444 ML/year.

Due to the variability of these inflows however - particularly in the 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.

5.4 NVIRP mitigation water

As previously noted, the NVIRP will reduce outfall volumes to wetlands by 85% due to increased efficiencies in the irrigation system. The volume of water that is required to offset the impact of NVIRP on wetlands that have become reliant on this water to support high environmental values is termed 'mitigation' water. As previously noted, the potential impact of NVIRP considered in the Johnson Swamp EWP is related to a reduction in outfalls only. Other potential impacts to the wetland will be managed through the Water Change Management Framework and Site Environmental Control Maps.

Guiding principles for mitigation water based on government policy have been defined by the NVIRP Technical Advisory Committee (TAC). These include:

1. Water savings are the total volumes saved less the volumes of water required to ensure no net impacts on high environmental values i.e. net savings.
2. Utilising the same baseline year (2004-2005) as that used to quantify savings, taking into account the long-term average annual patterns of availability.
3. Reliability of the mitigation water will match that of the source (outfall water).
4. The mitigation water should be represented as an obligation in the water corporation's bulk entitlement and should be deployed according to the EWP.

Although there are principles surrounding the concept of mitigation water, at the time of development of the Johnson Swamp EWP there was no agreed method to quantify the volume of outfall water that is considered to be providing an environmental benefit.

In the majority - if not all - cases, actual outfall volumes will be less than what is required to support the environmental values of a particular wetland. Therefore, the outfall water only forms part of the overall volumes required to provide the watering regime of the wetland. It is not possible to apportion parts of a wetland's watering regime to a particular value or set of values. The watering regime supports processes and systems which in turn provide suitable conditions for defined ecological values (e.g. breeding of waterbirds). Consequently, the mitigation water will be calculated based on a qualitative assessment supported by data and information on the values that a wetland supports, and the hydrological information available at the time.

A process for calculation of mitigation water based on the best available information has been developed and applied to Johnson Swamp (Appendix G and Section 5.4.1). This process involves the application of series of steps that includes:

Step 1: Quantifying the hydrological characteristics of the wetland

Step 2: Identifying the potential benefits of the outfall water

Step 3: Applying a set of criteria to determine whether all or part of the outfall water needs to be set aside to support the environmental values

Step 4: Calculating the volume of mitigation water with respect to the proposed wetland watering regime

Step 5: Calculating the net savings (outfall water less mitigation water)

The volume of mitigation water (Section 5.4.1) presented is based on the outfall water volume for the baseline year (2004-2005). The method for calculating water savings and application of the long-term cap equivalent (LTCE) was not available at the time of development of the Johnson Swamp EWP. The processes and advice on how to calculate mitigation water will be included in the 'Technical Water Savings Manual' which is currently being developed by DSE. Information to date suggests that mitigation water will be expressed as a volume with no reference to timing or quality.

The final volume of mitigation water agreed upon will be the result of negotiations between NVIRP and the environmental water manager, and confirmed by the NVIRP TAC.

5.4.1 Johnson Swamp mitigation water

The total inflows to Johnson Swamp from rainfall and catchment surface run-off (713ML/year) and outfalls (92.5 ML/year) are 805 ML/year. The impacts of a reduction in outfall inflows have been assessed according to the steps outlined previously. The results of which are presented below.

Step 1: Define hydrological characteristics of wetland

The hydrological characteristics of Johnson Swamp detailed in Section 4 and Appendix F are summarised in Table 9.

Table 9: Hydrological characteristics of Johnson Swamp

Johnson Swamp	Data
Wetland Capacity (FSL)	1783 ML
Minima/maxima volume required for recommended water regime	3436 to 4072 ML
Inflows	
Rainfall	652 ML/yr
Surface run-off	61 ML/yr
Outflows	
Estimated seepage (on filling)	255 ML
Annual evaporation	2 to 7 mm/year or on average 1530 ML/ year
G-MW Outfall Records	
Outfall Volume (2004/05 base year):	92.5 ML
Outfall Volume (98/99 to 07/08 median calculation):	132.5 ML

Step 2: Estimate potential benefits of outfall water

Figure 8 illustrates the managed inflows (outfalls and EWA) to the wetland since 1998.

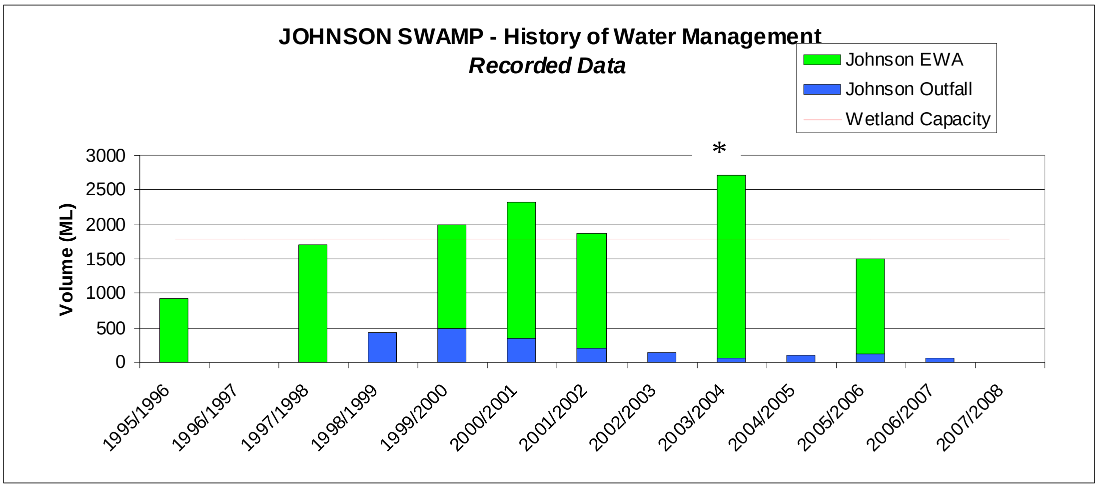

Figure 8: Johnson Swamp watering regime (1995-2008)

Step 3: Applying a set of criteria to determine whether all or part of the outfall water needs to be set aside to support the environmental values (NVIRP, 2009).

As defined in the Water Change Management Framework (NVIRP 2009), mitigation water is the water required to ensure no net impacts due to NVIRP on high environmental values. Mitigation water is required for a wetland with high environmental values except if the following criteria apply.

Table 10: Mitigation water assessment criteria

Criteria by which mitigation water may be assessed as zero
Mitigation water may be assessed as zero where: • there is no hydraulic connection (direct or indirect) between the irrigation system and the wetland or waterway • the water does not reach the wetland or waterway with environmental values (e.g. the outfall is distant from the site and water is lost through seepage and evaporation before reaching the area with environmental values) • the margin of error in the estimate of mitigation water is greater than the savings available from the relevant system operating component (e.g. the specific outfall) Mitigation water may be assessed as zero where the wetland or waterway receives water from the irrigation system: • 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) • during a season that is detrimental to the environmental values • 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 Mitigation water may be assessed as zero where the environmental values: • 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) Mitigation water may be assessed as zero where the removal of the contribution from the irrigation system does not: • increase the risk of reducing the environmental values (e.g. outfalls from a very small proportion of the water required to support the environmental values and their removal will not increase the level of risk) • result in the Environmental Water Manager being required to deploy additional water to the wetland or waterway in the future in order to offset the removal of the irrigation system contribution.

Each of the above criteria was considered with respect to outfall water and Johnson Swamp. The outputs of the assessment are presented in Table 11.

Table 11: Johnson Swamp and relationship to outfall water.

Link between outfall water (losses) and environmental values
1. The outfall water is received directly by Johnson Swamp.
2. The outfall water (04-05 value) accounts for 4% of the total volume required to fill to FSL. Therefore, it is not considered to be a demonstrably significant proportion of the overall water regime. The proportion for topping-up the open water assemblage is 10% (max.).
3. Outfalls have been regularly supplied to the wetland in large volumes (pre 2000s).
4. The site does not have more water than is required to support the desired state of the environmental values even if operated under a drier regime.
5. The losses occur at a time when they would counteract high evaporation rates (over the summer period).
6. Losses were not of particular low water quality, although turbidity of water could be an issue.
7. The losses reach the site, supporting an area of cumbungi, Phragmites, lignum and scattered willows.
8. Removal of losses would not have demonstrable impacts on the high environmental values of the wetland.
9. Johnson Swamp is an internationally significant wetland being part of the Kerang Lakes Ramsar site. It supports significant waterbird diversity and abundance.
10. Additional water would need to be supplied to top- up the wetland or additional water would need to be supplied to wet the bed prior to filling. However, this is only a very small proportion of the overall volumes required. Therefore, the potential opportunity costs are considered to be very small on filling and relatively small when topping-up the open water assemblage area.

The assessment process for calculation of mitigation water for Johnson Swamp suggests that mitigation water is not required to maintain the environmental values of the wetland. Due to the low volumes of outfall water supplied to the wetland over the past 10 years in comparison to the volumes required to support the wetland's environmental values, it is reasoned that outfalls are not supporting high environmental values at the site and therefore, there is no requirement on NVIRP to provide mitigation water for this wetland. The site assessment supports this, as only an area of Phragmites, Lignum and Willows were identified as being supported by the outfall water. These species are not significant and are not identified in the ecological objectives for the wetland.

Step 4: Calculating the volume of mitigation water with respect to the proposed wetland watering regime

The Johnson Swamp watering regime recommends filling the wetland to capacity one in five years and maintaining the open water assemblage for 15-18 months to a depth of at least 30 cm. The proposed mitigation water is presented in Table 12.

Table 12: Johnson Swamp water requirements

Year	Water regime	Volume required (max)[2]	Outfall (2004/05 baseline year)[1]	Proposed mitigation water
1	Fill to FSL ≥1.5m	3005 ML[4]	92.5 ML	0 ML
2	Top-up to maintain levels for 18 months (from initial inundation).	1067 ML	92.5 ML	0 ML
3	Allow to dry	0 ML	92.5 ML	0 ML
4	Maintain dry	0 ML	92.5 ML	0 ML
5	Maintain dry	0 ML	92.5 ML	0 ML
Total		**4072 ML**	**462.5 ML**	**0 ML (0 ML/year)**

Note 1: Long Term Cap Equivalent (LTCE) to assess the overall average annual patterns of availability is not included.
Note 2: maximum volumes presented i.e. surface in-flows and rainfall not included.
Note 3: in year six the wetland is filled again and therefore will return to cycle above (year one).
Note 4: equivalent to volume to fill plus volume to maintain open water assemblage in year one.

Step 5: Calculating the net savings (outfall water less mitigation water)

The potential water savings for NVIRP are defined in Table 13.

Table 13: Net water savings for Johnson Swamp

	Water savings
Year 1	92.5 ML
Year 2	92.5 ML
Year 3	92.5 ML
Yaer 4	92.5 ML
Year 5	92.5 ML
Average	**92.5 ML/year**

The average annual net water savings based on the recorded 2004/05 baseline year outfall volume of 92.5 ML/year for Johnson Swamp is 92.5 ML/year.

5.5 Other Water Sources

As discussed in Section 5.4, the calculated mitigation water is only a small portion of the overall volumes required to provide the recommended watering regime for Johnson Swamp and does not support any significant environmental values. No provision of mitigation water is proposed for Johnson Swamp.

As Johnson Swamp no longer receives water from Pyramid Creek except in major floods, it is almost entirely dependant on artificial watering via the outfall channel. Regulated inflows are therefore the primary means through which it will receive water. Other sources of water will need to be secured in the years that the wetland is scheduled to be filled. The most likely sources for this water will be existing or future environmental entitlements. Existing Victorian government water recovery commitments to the Living Murray and Snowy River initiatives together with water recovery projects will provide about 900 GL of water that will be made available for northern Victorian rivers and wetlands. Potential environmental water sources for Johnson Swamp are discussed in brief below.

5.5.1 Murray flora and fauna bulk entitlement

In 1987, an annual allocation of 27,600 ML of high security water was committed to flora and fauna conservation in Victorian Murray wetlands. In 1999, this became a defined entitlement for the environment (DSE 2006). Each year, a prioritisation process is utilised to decide on the best use of the available water (based on River Murray allocations). An annual distribution program identifies wetlands that will receive a portion of the entitlement utilising a decision flowchart (DSE 2006). Johnson Swamp has historically received environmental water from this entitlement to support feeding and breeding habitat for waterbirds. In the decision flowchart for this entitlement, consideration is first given to whether Hird or Johnson Swamp requires water (DSE 2006b). Therefore, it is expected that Johnson Swamp will have a high probability for receiving water from the 27,600 ML entitlement.

5.5.2 175GL environmental entitlement

It is predicted that water savings generated by the modernisation project will provide up to 175GL for the environment, which will be used to help improve the health of priority stressed rivers and wetlands in northern Victoria (DSE 2008). The 175 GL saved as a result of the project will be converted into a statutory environmental entitlement with a designated Environmental Water Holder responsible for holding and managing the entitlement (DSE 2008). The entitlement will also have properties which enable the water to be used at multiple locations as the water travels downstream (provided losses and water quality issues are accounted for). This means that the water can be called out of storage at desired times to meet specific environmental needs.

The use of the environmental entitlement will be managed as part of an existing overall framework which aims to allocate environmental water to its highest value environmental use each year. Existing criteria (likely outcomes from the watering on ecological objectives, the significance of outcomes, watering history, risks and financial costs) for utilisation of environmental water ensures maximisation of environmental outcomes for high-value sites. More recently, under drought conditions consideration has been given to avoiding critical loss of species and catastrophic events in addition to the provision of drought refuges (DSE 2008d).

5.5.3 Commonwealth Environmental Water

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

The *Water Act 2007* provides that “the Commonwealth Environmental Water Holder must perform its functions for the purpose of protecting or restoring environmental assets so as to give effect to relevant international agreements”. Wetlands listed as of International Importance (Ramsar) are considered priority environmental assets for use of the commonwealth environmental water (DEWHA 2008). Therefore, it is expected that Johnson Swamp as part of the Kerang Wetlands Ramsar site will be considered a priority site for use of the Commonwealth Environmental Water.

6. Potential risks or adverse impacts

Identification of the potential risks and limiting factors associated with the provision of the recommended watering regime for Johnson Swamp is important. Table 14 identifies the potential risks or limiting factors and impacts that may result from the implementation of, or in association with, the recommended watering regime. This information was reviewed during the EWP workshop held on 19 March 2009.

Mitigation measures have been recommended to reduce the likelihood of the risk occurring and/or the degree of impact it may have.

Table 14: Potential risks, impacts and mitigation measures associated with the recommended water regime for Johnson Swamp

Risks/limiting factors	Impacts	Mitigation measures
Delivery of Water		
Limited water availability	Failure to achieve identified management objectives	Ensure sufficient information is collected for prioritisation of Johnson Swamp in environmental allocation processes Review rainfall and climate data to utilise natural inflows where possible.
Ineffective outfall delivery	Prolonged dry period in deep area of the wetland	Upgrade of outlet structure to Pyramid Creek is required to enable more effective water delivery.
Climatic variability	Variability in water availability (e.g. wet seasons during a planned dry phase)	Adaptive management of watering regime and delivery options as above.
Poor water quality (i.e. high turbidity, salinity and nutrient levels)	Reduced primary production (turbid water), limiting food resources for aquatic invertebrates and waterbirds. Encroachment of nutrient tolerant vegetation Common Reed and Cumbungi Excessive algal growth	Monitoring of groundwater levels, salinity and nutrient inputs and adaptive management of watering regime.
Groundwater intrusion due to elevated groundwater levels	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. Adaptive management of watering regime.
Lack of connection between wetland and a river or floodplain	Altered flow regime (continued lack of flood flows) Lack of flora and fauna sources for repopulation	Investigate opportunities to reconnect Johnson Swamp to the river and floodplain
Flooding of adjacent landholders	Community angst Liability	Monitor rainfall and climate data and adapt water delivery to account for potential flood events.
Ecological Response		
Uncertain groundwater height and salinity levels	Saline groundwater intrusion	Groundwater monitoring and adaptive management of recommended watering regime
No reliable supply of food/nesting sites	Limited occurrences of waterbirds	Seasonal water delivery, monitoring and adaptive management of watering regime

Risks/limiting factors	Impacts	Mitigation measures
Lag time between wetland watering and bird breeding	No successful breeding events	Seasonal water delivery, monitoring and adaptive management of watering regime
Encroachment or dominance of native flora species	Monoculture of Common Reed and Cumbungi	Active management (spraying, slashing, crash grazing etc)
	Monoculture of *Persicaria* (knotweed)	
	Loss in species diversity	
	Habitat loss	
	Watering events prove unproductive for waterbirds	Seasonal water delivery, monitoring and adaptive management of watering regime
Proliferation of pest plants and animals	Reduced habitat and resource availability	Monitoring, Active management (weed and pest control), carp screens
	Predation	
	Limited establishment of native vegetation	
Lack of seedbank viability	Emergence of unexpected native or exotic species	Monitoring and adaptive management. Potential to test seed germination (samples taken from wetland bed)
	Restricted regeneration	Monitoring and adaptive management. Consider seeding if necessary
	Limited regeneration and dominance of salt tolerant species	
High soil salinity	Poor vegetation health	Monitoring and adaptive management of recommended watering regime to reduce potential groundwater intrusion.
	Limited regeneration and dominance of salt tolerant species	
	Poor vegetation health	
	Limited regeneration and dominance of salt tolerant species	
Other		
Recreational pressures e.g. hunting increases in response to watering event	Loss of non-game species	Monitoring of waterbird numbers and diversity. Reporting of information to relevant bodies including Field and Game and DSE.
Fire	Habitat and resource loss	Active management, monitoring and adaptive management
	Deteriorating water quality	

7. Water delivery arrangements

Delivery of water at appropriate times and in the required quantities is dependant on having appropriate infrastructure and access to spare channel capacity when required.

The 4/7/2 channel that supplies Johnson Swamp has a reported capacity of 100 ML/day. The outfall structure (drop-bar) located on the western side of the lake (Figure 9) has a reported capacity of 70 ML/day. Johnson Swamp also has a 600mm outlet (east side) with a door to drain into Pyramid Creek. This structure supports the draw-down of the wetland if excessive inundation threatens Black Box survival (prolonged inundation; Black Box can survive an inundation of three months, and show stress at 13 months).

At a flow rate of 70 ML/day it will take a minimum of 20 days to fill Johnson Swamp from empty subject to the availability of water, and the ability of the G-MW system to deliver flows in conjunction with competing customer demands.

There is less demand for channel capacity in the winter/spring period when it is the optimum time for delivery of environmental water. However, arrangements for water delivery will need to be adaptively managed as part of the annual operational planning for the wetland (refer to section 8).

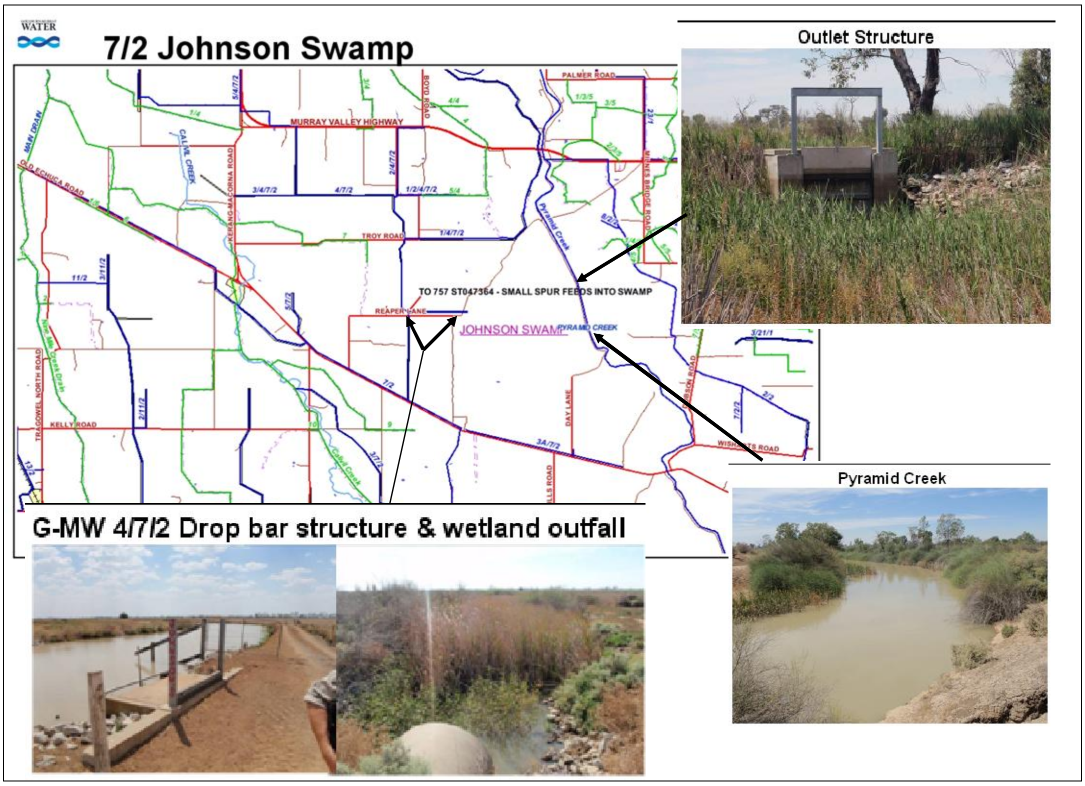

Figure 9: Johnson Swamp infrastructure

7.1 NVIRP works program – channel 4/7/2

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

The Johnson Swamp outfall structure is located on the Torrumbarry channel 4/7/2 which is part of the automated backbone. The outfall structure will be replaced as part of the backbone automation works.

The automation works on the 4/7/2 channel are planned to be undertaken in the winter of 2010.

7.2 Infrastructure recommendations

Potential upgrade options to improve operational management of Johnson Swamp water delivery infrastructure include:

- The replacement of the existing drop-bar outfall structure to a fully automated structure. This will improve operational management by minimising losses (bar leakage) and enhancing safety and useability. It is estimated that upgrading this structure would cost approximately $60,000 (Robert Chant, G-MW, pers comm. 2009).
- Upgrade of the outlet structure to a versatile structure to enable both delivery and drainage. This would allow direct delivery of water from Pyramid Creek to the open water assemblage area. Further scoping of this option is required - pumping may be required due to the deepened and altered course of the creek.
- Excavation from the outfall structure to enable direct delivery into the open water assemblage from the 4/7/2 channel is not recommended due to the bathymetry of the wetland (flat and undulating).

Common Carp are abundant within the G-MW channel system and there is currently no carp screen from the channel system to Johnson Swamp. Carp are known to have significant detrimental impacts on wetlands by increasing the turbidity of the water, preventing the establishment of aquatic vegetation and competing with native species.

It is recommended that a carp screen is installed when upgrading the outfall structure to prevent carp entering the wetland. A screen with a spacing size of 50 mm would minimise blockage while restricting the passage of large breeding sized carp (SKM 2005). Although it would not totally exclude the passage of carp it will significantly reduce the population size, facilitating regeneration of wetland vegetation. The following should be considered prior to installation:

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

Note: A carp screen will also need to be considered at Pyramid Creek, unless environmental water is pumped to the wetland.

As the NVIRP does not have an obligation to supply mitigation water, the works recommended above will need to be funded and undertaken outside of this project.

8. Adaptive management framework

Predicting a wetland's response to watering is difficult, as the interactions between water regimes, processes and biota are extremely complex. The relationships between the various components have been described in the Johnson Swamp EWP by relating the ecological objectives to hydrological objectives, and describing the overall watering regime required to achieve the goal for the wetland.

There is no mitigation water volume recommended for Johnson Swamp. Therefore, NVIRP and the water corporation (in subsequent years) do not need to demonstrate that this volume is being provided or that it has mitigated against potential impacts from NVIRP. However, adaptive management of the recommended watering regime should be undertaken.

Adaptive management will provide the means through which the EWP and watering decisions will be refined over time as new information and data become available.

It is important that an adaptive management approach is undertaken for the implementation of the EWP to ensure that it is responsive to changing conditions. The proposed adaptive management framework for Johnson Swamp is shown in Figure 10.

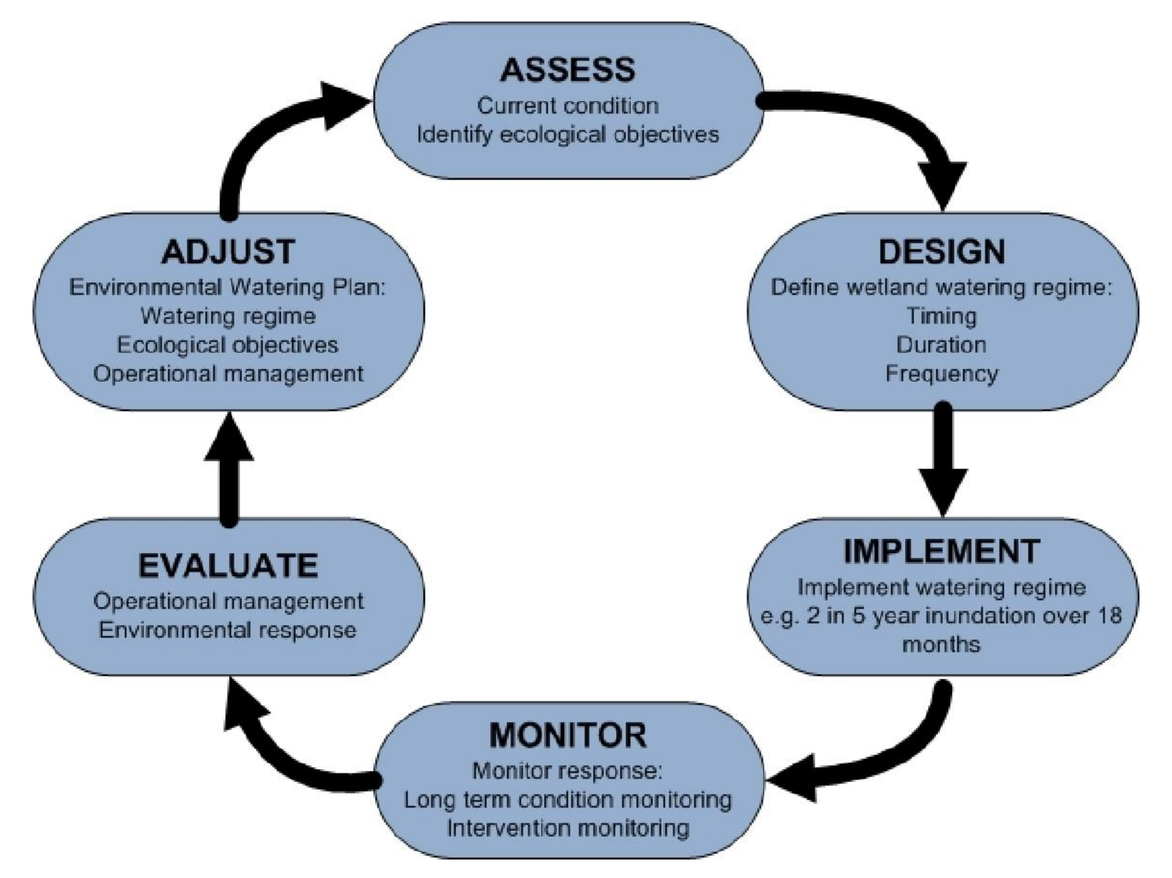

Figure 10: Adaptive Management Framework

8.1 Assess and design

The assess and design phases (Figure 10) of the adaptive management framework have been completed as part of the development of the EWP. The 'assess' phase involved assessing current condition, identifying ecological objectives and determining their respective water requirements. The 'design' stage involved identifying the required watering regime and any risks associated with its provision.

8.2 Implement

The implementation phase (Figure 10) will occur through the active management of environmental water delivery to the wetland.

8.3 Monitor

A critical component of the adaptive management of Johnson Swamp is developing and implementing a monitoring program to determine the effectiveness of the recommended watering regime in achieving the ecological objectives.

It is beyond the scope of the EWP to recommend a detailed monitoring program for Johnson Swamp. However, two types of monitoring for the wetland are recommended to assess the effectiveness of the proposed water regime on objectives and to facilitate adaptive management:

- long-term condition monitoring
- intervention monitoring.

Long-term condition monitoring will provide information on whether the watering regime (and other factors) is causing a change in, or maintaining, the overall condition of the wetland (trend over time). Some suggested components for long-term condition monitoring are provided in Appendix G.

Intervention monitoring will assess the response of key environmental values to the provision of water (intervention) and the achievement of ecological objectives e.g. waterbird feeding and/or breeding. Intervention monitoring may include monitoring of water quality, vegetation and key biota (e.g. waterbirds, fish and invertebrates). Monitoring the response to a watering event will be important to provide feedback on how the system is responding and whether any amendments need to be made to operational management, e.g. top-ups to maintain levels in the open water area for aquatic plants and waterbirds.

It is important to note that previous management reports have provided more detailed guidelines for the monitoring of Johnson Swamp and should be referred to prior to implementation of any monitoring program. In particular SKM (2001) has provided a detailed decision framework for managing the watering regime in any one year depending on the biota response and groundwater levels. In addition, the document prescribes monitoring for key variables including water quality, nutrients and biota.

8.4 Evaluate

The monitoring results will need to be evaluated with respect to predicted outcomes and responses. Evaluation should occur on two components:

- Operational management i.e. whether the volumes estimated as part of the surface water balance are achieving the hydrological objectives e.g. required durations and depth.
- Environmental responses i.e. whether the recommended watering regime is resulting in the predicted responses e.g. waterbird feeding.

8.5 Adjust

In light of the monitoring information in addition to any new knowledge, this phase will involve determining whether changes are required to operational management (i.e. volumes and operational arrangements to achieve watering regime), to expected outcomes (i.e. ecological objectives), or to cope with unexpected issues. These changes will need to be incorporated into the EWP.

The EWP will be reviewed following the first year of implementation, and every five years thereafter, or at any time requested by the Minister for Water.

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 15 (NVIRP, 2009). The table outlines the roles and responsibilities before and during the implementation of NVIRP in the modified GMID.

Table 15: Roles and responsibilities

Agency	Assess and develop management and mitigation measures	Deliver and review management and mitigation measures during NVIRP implementation
NVIRP	• Lead the assessment and development processes for management and mitigation measures. • Maintain short-list of all wetlands, waterways and groundwater dependent ecosystems for mitigation and their status. • Identify and source mitigation water required to implement management and mitigation measures including the development of EWPs where required. • Maintain or provide infrastructure to deliver water to wetlands and waterways. • Convene and chair the Technical Advisory Committee. • Convene the Expert Review Panel	• Provides resources to enable monitoring and review of management and mitigation measures until completion of NVIRP works. • Establish protocols for transfer of responsibility to relevant agencies. • Coordinate with other agencies to improve management and mitigation measures until completion of NVIRP works. • Arrange for the provision of delivery infrastructure including capacity and operational flexibility for mitigation water.
Catchment Management Authority	• Identify and inform NVIRP of opportunities for best practice. • Inform NVIRP of its infrastructure requirements to deliver environmental water. • Participate in Technical Advisory Committee. • Agree to implementing relevant components of Environmental Watering Plans. • Agree to implementing other relevant regional management and mitigation measures required due to the implementation of NVIRP.	• Advise Environmental Water Holder and system operator on priorities for use of environmental entitlements (including mitigation water) in line with recommendations outlined in the EWPs • Implement the relevant components of Environmental Watering Plans. • Operate, maintain and replace, as agreed, the infrastructure required for delivery of mitigation water, where the infrastructure is not part of the G-MW irrigation delivery system. • Report on environmental outcomes (e.g. wetland or waterway condition) from the delivery of the water, in the course of normal reporting on catchment condition. • Where agreed conduct the periodic review of EWPs and report results to NVIRP. • Manage and report on other relevant regional management and mitigation measures required due to the implementation of NVIRP.

Agency	Assess and develop management and mitigation measures	Deliver and review management and mitigation measures during NVIRP implementation
Land Manager	• Identify and inform NVIRP of opportunities for best practice. • Participate in Technical Advisory Committee. • Agree to implementing relevant components of Environmental Watering Plans. • Agree to implementing other relevant regional management and mitigation measures required due to the implementation of NVIRP.	• Implement the relevant components of Environmental Watering Plans. • Operate, maintain and replace, as agreed, the infrastructure required for delivery of mitigation water, where the infrastructure is not part of the G-MW irrigation delivery system. • Where agreed, participate in the periodic review of relevant EWPs. • Manage and report on other relevant regional management and mitigation measures required due to the implementation of NVIRP.
System Operator	• Identify and inform NVIRP of opportunities for best practice. • Participate in Technical Advisory Committee. • Agree to implementing 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 water, where the infrastructure is part of the G-MW irrigation delivery system. • May negotiate transfer of ownership of infrastructure to the environmental water/land manager for provision of mitigation water if it is no longer required for the public distribution system. • Where the infrastructure assets are due for renewal or refurbishment, the water corporation will undertake the upgrade to the best environmental practice, including any requirements to better provide Environmental Water Reserve. • Report annually on the 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 meter mitigation flows to ensure mitigation volumes of water are delivered.

DSE	• Identify and inform NVIRP of opportunities for best practice.
	• Participate in Technical Advisory Committee.
	• Arrange funding to enable environmental water manager and land manager to deliver agreed measures.
		• Participate in the periodic review of the Water Change Management Framework and relevant EWPs.
		• Conduct review as part of the long-term water resource management, a requirements specific in Section 22L of the *Water Act 1989*. The process will allow:
		  - the balance of the environmental obligations and consumptive water to be assessed and restored based on certain conditions.
		  - the need for the obligation reviewed based on the environmental values at the time of the review.

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

9.1 Framework for operational management

Delivery of environmental water to Johnson 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 11. This has been developed to describe the decision-making process required to coordinate implementation of the recommended watering regime for Johnson Swamp.

The main components are:

- Assessment of current conditions i.e. status of wetland, 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.

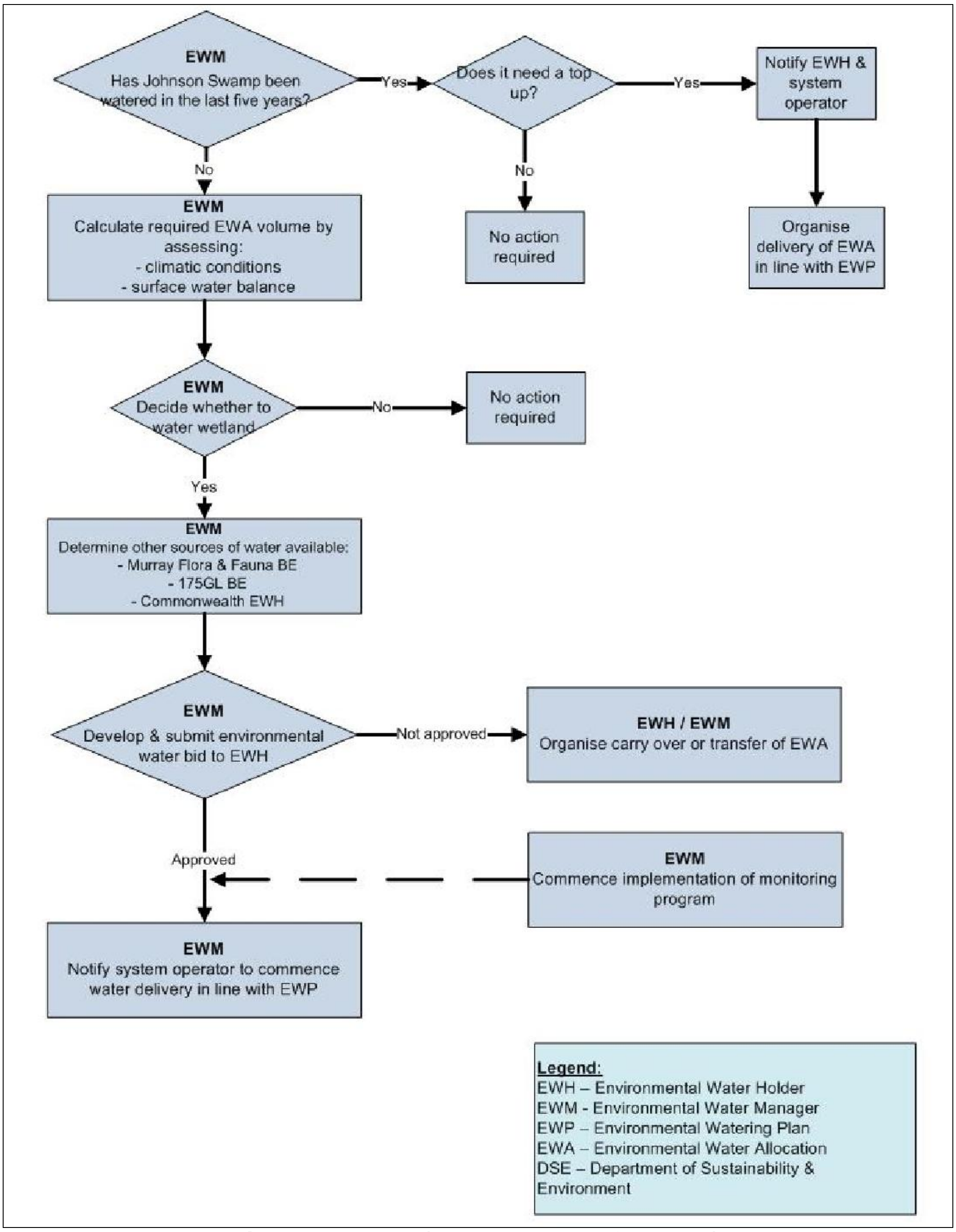

Figure 11: Operation management framework

10. Knowledge gaps

The Johnson Swamp EWP has been developed utilising 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 Johnson Swamp

- Continued monitoring and evaluation of groundwater and surface water data is recommended to ensure no detrimental impacts from implementation of the watering 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.

10.2 Roles and responsibilities

The roles and responsibilities of key agencies in the operational management of mitigation water have not yet been clearly defined. A process has been recommended (Section 9.2). However, in light of significant possible policy changes in Victoria (i.e. Northern Region Sustainable Water Strategy and Biodiversity White Paper), roles and responsibilities may need to be reviewed.

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Appendix A: NVIRP TAC and Wetland workshop participants

Table A1: NVIRP TAC members

Name	Organisation and Job title
Anne Graesser	Manager – Water Systems Health Goulburn Murray Water
Chris Solum	Environmental Program Manager NVIRP
Emer Campbell	Manager – NRM Strategy North Central CMA
Jen Pagon	Environmental Program Leader Department of Primary Industries
John Cooke	Manager Sunraysia Department of Sustainability and Environment
Ken Sampson	Shepparton Irrigation Region Executive Officer Goulburn Broken CMA
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
Michelle Bills	Strategic Environmental Coordinator North Central CMA
Paulo Lay	Senior Policy Officer Department of Sustainability and Environment

Table A2: Wetland workshop participants – 19 March 2009

Name	Organisation and Job title
Andrea Joyce	Program Leader – Wetlands and Environmental Flows Department of Sustainability and Environment
Anne Graesser	Manager – Water Systems Health Goulburn Murray Water
Chris Solum	Environmental Program Manager NVIRP
Emer Campbell	Manager – NRM Strategy North Central CMA
Geoff Sainty	Wetland Specialist Sainty and Associates Pty Ltd
Jo Deretic	Regional Wetland Coordinator Department of Primary Industries
Karen Weaver	Biodiversity and Ecosystem Services Department of Sustainability and Environment
Keith Chalmers	Wetland Officer Department of Primary Industries
Mark Tscharke	Senior Ranger Parks Victoria
Michelle Bills	Strategic Environmental Coordinator North Central CMA
Paulo Lay	Senior Policy Officer Department of Sustainability and Environment
Rebecca Lillie	Environmental Scientist (Ecology) Kellogg Brown and Root
Rob O'Brien	Senior Environmental Officer Department of Primary Industries
Rohan Hogan	Science & Strategy Leader North Central CMA
Shelley Heron	Manager – Water Ecosystems Kellogg Brown and Root
Tamara Boyd	State Parks and Environmental Water Coordinator Parks Victoria
Tim Shanahan	Team Leader – Irrigation and Water Resources North Central CMA

Appendix B: Community Interaction/Engagement

Rob O'Brien, Department of Primary Industries

Background and Purpose

EWPs are currently being developed for three wetlands in the Kerang–Boort area to determine the ecological impact of the current irrigation outfall (surplus water). An important component of this work involves identifying the environmental objective and wetland type for each of these wetlands. This requires an understanding of physical attributes, the history and the main biological processes associated with each of the wetlands.

There have been various levels of planning and monitoring on each of the wetlands currently being studied. To assist in collating all relevant information on each wetland it is important to capture and record information from the local community. In many cases adjoining landholders have had a long association with a wetland and have developed good understanding that is useful to include in the development of the plan. This is particularly important if only limited monitoring records exist.

This process is also useful to increase community ownership and acceptance of the EWP, particularly if ongoing work involves onground works.

These plans are required to be developed over a relatively short timeframe (6–8 weeks). To achieve the best result, a targeted community/agency engagement process was developed where a list of people with a good technical understanding of the wetland was developed by the technical working group.

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

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

The information is captured in brief dot point form and only technical information and observations have been noted that will add value to the development of the plan.

A list of participants has been recorded; however, comments for each wetland have been combined so individual comments are not referenced back to individuals.

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:

Information Provided to Participants

We are currently completing a study for NVIRP Northern Victoria Irrigation Renewal Project. It involves completing plans for Lake Murphy, Lake Elizabeth and Johnson Swamp.

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 is recognised that these wetlands have been altered significantly since European settlement and the expansion of irrigated agriculture.

Providing information on these changes and how they 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 influence the floodplains and wetland.
- What connection does the wetland have to the floodplain in providing floodwater or local catchment runoff?

- To what extent does the current irrigation supply channel impact the water regime over time?
- During more recent times (i.e. last 50 years) 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 (box thorns, willows, cumbungi, etc.)
- What influence – both positive and negative – has grazing domestic stock had on reserve?
- 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?

List of Community & Agency Participants

- Stan Archard (Field & Game Australia)
- Chris Coleborn (Birds Australia Member)
- Greg Wood (previous Adjoining Landholder)
- Mark Tscharke (Parks Ranger)

Comments & Feedback from Participants for Johnsons Swamp

- Johnsons Swamp, like Hird Swamp is feed by the Pyramid Creek system.
- Kow Swamp and the Pyramid Creek receive water from the Bendigo Creek and water that sheds off the Patho Plains area, then into Taylors Creek.
- Johnsons Swamp was much deeper when it operated as part of the Pyramid Creek, prior to dredging.
- High flows down the Pyramid Creek would lift the water levels up in the creek, flooding Johnsons Swamp.
- Johnsons Swamp water levels didn't seem to fluctuate much prior to dredging (68/69) as there were many wet years where water continually flowed high in the creek and entered the swamp systems.
- There were large open water sections within Johnsons Swamp, much more open than Hirds Swamp.
- The Pyramid Creek and associate wetlands were mostly shallow systems and were a haven for waterbirds (pre dredging)
- The smaller Johnsons Swamp East on the other side of the Pyramid Creek is a Lignum swamp with a Black Box perimeter and does not receive any water.
- As Johnson Swamp East became drier, lignum took over.
- The most common emerging water plants within the Pyramid Creek system, prior to dredging, were Club Rush and Cumbungi and they provided great habitat for nesting waterbirds. Phragmites was inconspicuous however there was a small patch at the north end of Johnson's Swamp.
- Redfin (a few Tench) became the dominant fish species in the Pyramid Creek and perhaps in some of the deeper sections of the adjoining wetlands like Johnsons Swamp.
- Redfin were a highly prized eating fish and large numbers were caught by “Bobbing” off Milnes Bridge, downstream from Johnson Swamp.
- Few native fish were caught in the Pyramid Creek as the Redfin and later European Carp wiped them out.

- After the Pyramid Creek was dredged the section under Milnes Bridge remained shallow and coloured fish (carp) could be seen under the bridge and the carp caused the Redfin disappeared
- The dredging of the Pyramid Creek allows floodwater to get away more quickly and reduces the length of inundation of the associated swamps.
- The late Des Thomas (OMA) and Ken Hooper fought hard to protect Hird & Johnsons Swamp after the dredging of the Pyramid Creek.
- Des, Ken and other local Field & Game members were successful pressuring government to construct a bound bank along the Pyramid Creek so the Johnsons & Hirds Swamp could hold water and they also managed to get a specific environmental water allocation of 2,600 ML for Hird and Johnsons
- There may be a need to increase the full supply level at Johnsons Swamp; this may discourage the expansion of Phragmites and Cumbungi.
- The Pyramid Creek and associated wetlands originally contained Black Box trees and therefore were only likely to flood periodically (i.e. not Red Gum).
- Phragmites is a huge problem at Johnsons Swamp and has taken over much of the wetland bed.
- It’s very difficult to develop a watering plan that will not result in the dominance of Phragmites and Cumbungi which have established in more recent times, since the dredging of the Pyramid Creek.
- Alternative methods such as fire and grazing might need to used to check the dominance of Phragmites.
- There is a need to start some types of improvement works at Johnsons Swamp soon.
- The islands that were constructed in Johnsons Swamp were planted up with trees and have been very successful
- There is a need to increase pest plant and animal works at Johnsons Swamp.
- The water regime for Johnson Swamp is difficult to establish due to the potential for Phragmites to take over, however will require a wet and dry cycle (not constantly wet).
- Fire could be an ongoing threat to this Swamp

Appendix C: Johnson Swamp – wetland characteristics

Characteristics	Description
Wetland Name	Johnson Swamp
Wetland ID	7726 3555320
Wetland Area	340ha
Conservation Status	Ramsar & Directory of Important Wetlands
Land Status	State Wildlife Reserve (primarily related to waterbirds)
Land Manager	Parks Victoria
Surrounding Land Use	Irrigated cropping and pasture
Water Supply	Natural: Pyramid Creek Current: Torrumbarry Irrigation System channel outfall (4/7/2) • 300EC • Capacity of 160ML/d (approx 18 days to fill)
1788 Wetland Classification	Shallow Freshwater Marsh (<8 months duration, <0.5m depth) Intermittent Black Box wetland
1994 Wetland Classification	Deep Freshwater Marsh (wet 4 in 5, <2.0m)
Recorded Significant Species	Refer to Table 1 and 2, Section 3.
Wetland Capacity	1783 ML– FSL 78.3 m AHD (Not including wetting up losses, e.g. seepage) *Depth of Wetland (Range): 0-1 metres*
Outfall Volumes	92.5 ML (04/05) 132.5 ML (98/99 to 07/08 median)

Appendix D: Flora and fauna species list

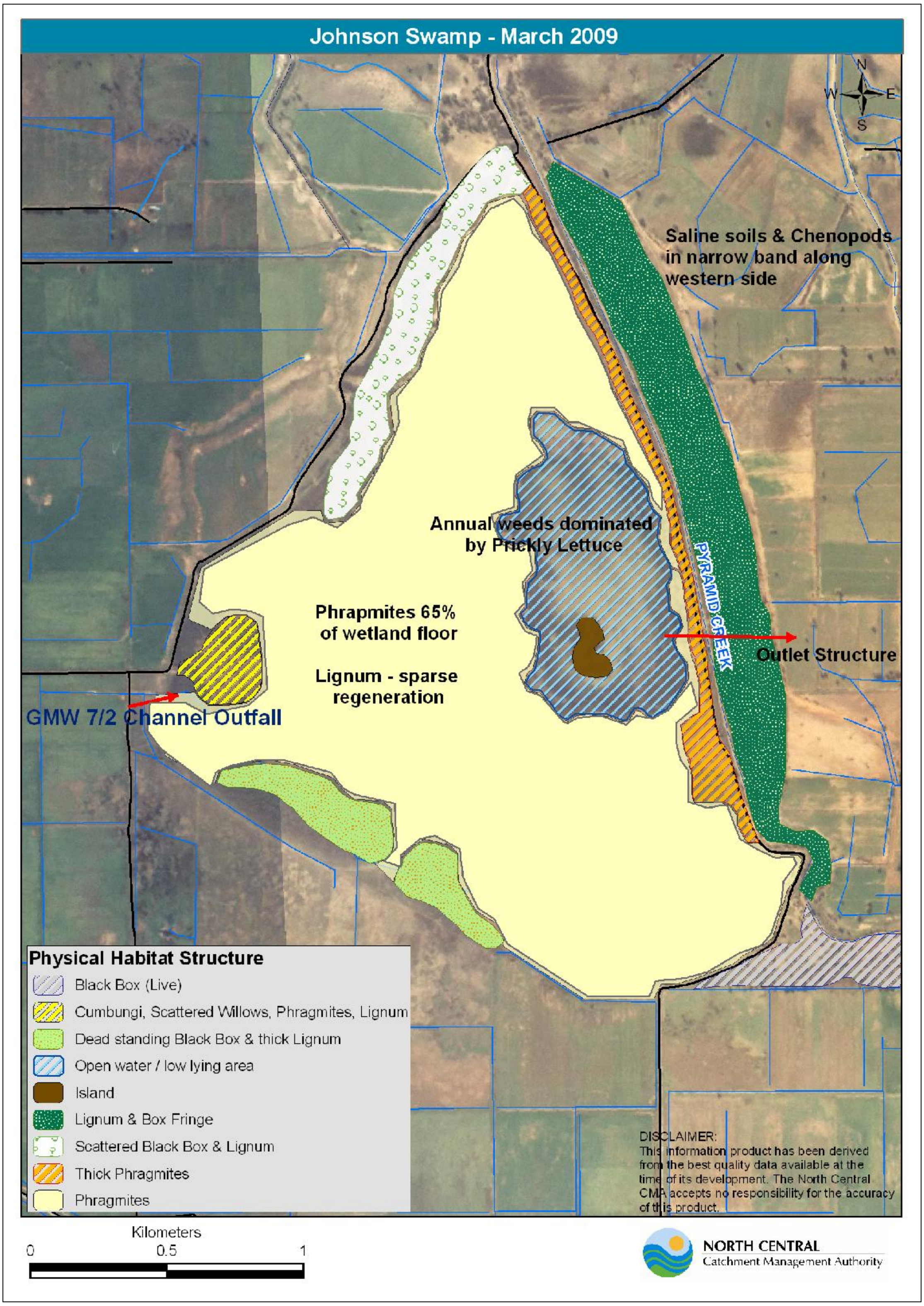
Common name	Scientific name	Dates recorded
Flora - Native		
Austral Mudwort	*Limosella australis*	1990
Berry Saltbush	*Atriplex sembicatta*	1997
Black Box	*Eucalyptus largiflorens*	1975, 1997, 1990, 2004
Black Roly-poly	*Sclerolaena muricata*	1997
Blackseed Glasswort	*Halosarcia pergranulata*	1997
Bladder Saltbush	*Atriplex vesicaria*	1997
Blown Grass	*Agrostis avenacea*	1990
Bonefruit	*Osteocarpum acropterum*	1990
Bristly Love-grass	*Eragrostis setifolia*	2004
Buckbush	*Salsola kali*	1990
Cane Grass	*Eragrostis australasica*	1990
Coarse Water Milfoil	*Myriophyllum salsugineum*	1990
Common Blown-grass	*Agrostis avenacea var. avenacea*	1997
Common Reed	*Phragmites australis*	1990, 1997, 2004
Cotton Fire Weed	*Senecio quadridentatus*	1990
Cottony Saltbush	*Chenopodium curvispicatum*	1997
Creeping Saltbush	*Atriplex semibaccata*	1990
Cumbungi	*Typha domingensis*	1997
Cumbungi	*Typha orientalis*	1997
Cumbungi	*Typha spp.*	1990
Dillon Bush	*Nitraria billardieri*	1990
Drooping Wattle	*Acacia difformis*	1986
Eel Grass	*Vallisneria spiralis*	1990
Ferny Azolla	*Azolla pinnata*	1990
Glasswort	*Halosarcia pergranulata*	1990
Green Algae	*n/a*	1990
Hoary Willow Herb	*Epilobium hirtigerum*	1990
Hyssop Loosestrife	*Lythrum hyssopifolia*	1990
n/a	*Lycium spp.*	1997
Nitre-bush	*Nitraria billardierei*	1997
Nodding Saltbush	*Einadia nutans ssp. nutans*	1990, 1997
Pacific Azolla	*Azolla filiculoides*	1990, 1997
Pale Knotweed	*Persicaria lapathifolium*	1990
Red Gum	*Eucalyptus canmaldulensis*	1990
Red Water Milfoil	*Myriophyllum verrucosum*	1990
Ribbon Weed	*ValisnDSE,a spiralis*	1990
River Club-rush	*Schoenoplectus validus*	1997
Rough Wattle	*Acacia aspera*	1997
Ruby Saltbush	*Enchylaena tomentosa var. tomentosa*	1990, 1997
Slender Fruited Saltbush	*Atriplex leptocarpa*	1990
Slender Knotweed	*Polygonum minus*	1990
Small Spike Rush	*Eleocharis pusilla*	1990
Spiny Saltbush	*Rhagodia spinescens*	1990, 2004
Stonewort	*Chara sp.*	1990
Stonewort	*Nitella sp.*	1990
Swamp Wallaby Grass	*Amphibromus neesii*	1990

Common name	Scientific name	Dates recorded
Tall Groundsel	*Senecio runcinifolius*	1990
Tangled Lignum	*Muehlenbeckia cunninghami*	1990, 1997, 2004
Thin-leaf Wattle	*Acacia aculeatissima*	1997
Tussock Rush	*Juncus articulatus*	1990
Tussock Rush	*Juncus flavidus*	1990
Water Ribbons	*Triglochin procerum s.l.*	1997
Flora - Exotic		
Annual Beard Grass	**Polypogon monspeliensis*	1990
Barley Grass	**Critesion murinum*	1990, 1997, 2004
Blue Barley-grass	**Critesion murinum*	1982
Bokhara Clover	**Melilotus alba*	1990
Burr Medic	**Medicago polymorpha*	1990, 1997
Bushy Starwort	**Aster subulatus*	1990
Celery Buttercup	**Ranunculus scleratus*	1990
Chickweed	**Stellaria media*	1990
Common Sow Thistle	**Sonchus oleraceus*	1990
Common Starwort	**Callitriche stagnalis*	1990
Curled Dock	**Rumex crispus*	1990
Drain Flat-sedge	**Cyperus eragrostis*	1997
Duckweed	**Lemna minor*	1990
Fat Hen	**Chenopodium album*	2004
Ferny Cotula	**Cotula bipinnata*	1990
Flat Weed	**Hypochoeris radicata*	1990
Giant Mustard	**Rapistrum rugosum*	2004
Great Brome	**Bromus diandrus*	1990, 2004
Hastate Orache	**Atriplex prostrata*	1990, 1997
Hexham Scent	**Melilotus indica*	1990
Meadow Barley-grass	**Critesion secalinum*	1982
Medic	**Medicago sp.*	2004
Mouse Eared Chickweed	**Cerastium glomeratum*	1990
Ox Tongue	**Helminthotheca echioides*	2004
Ox Tongue	**Picris echioides*	1990
Paradoxical Canary Grass	**Phalaris peradoxa*	1990
Peppercress	**Lepidium africanum*	1990
Prickly Lettuce	**Lactuca serriola*	1990, 2004
Prickly Sow Thistle	**Sonchus asper*	1990, 2004
Rats Tail Fescue	**Vulpia myuros*	1990
Rye Grass	**Lolium spp.*	1990
Scorzonera	**Scorzonera laciniata*	1990
Scotch Thistle	**Onopordum acanthium*	1990
Sea Barley Grass	**Critesion marinum*	1990
Slender Barb Grass	**Parapholis strigosa*	1990
Small Ice Plant	**Mesembryanthemum nodiflorum*	1990, 2004
Soft Brome	**Bromus hordeaceus*	1990, 2004
Soursob	**Oxalis pes-caprae*	2004
Spear Thistle	**Cirsium vulgare*	1990
Strawberry Clover	**Trifolium fragiferum*	1990
Water Buttons	**Cotula coronapifolia*	1990

Common name	Scientific name	Dates recorded
Water Couch	**Paspalum distichum*	1997
White Clover	**Trifolium repens*	1990
Wild Oats	**Avena fatua*	1990
Wimmera Rye-grass	**Lolium rigidum*	2004
Winged Slender Thistle	**Carduus tenuifloris*	1990
Wolley Clover	**Trifolium tomentosum*	1990
Fauna - Native		
Australasian Bittern	*Botaurus poiciloptilus*	Likely to occur (DSE, 2009)
Australasian Grebe	*Tachybaptus novaehollandiae*	1994
Australasian Shoveler	*Anas rhynchotis*	1987, 1988, 1989, 1994, 1999
Australian Little Bittern	*Ixobrychus minutus dubius*	Likely to occur (DSE, 2009)
Australian Painted Snipe	*Rostratula australis*	Likely to occur (DSE, 2009)
Australian Pelican	*Pelecanus conspicillatus*	1994
Australian Shelduck	*Tadorna tadornoides*	1977, 1987, 1992, 1999, 2004
Australian Smelt	*Retropinna semoni*	1989, 1990
Australian White Ibis	*Threskiornis molucca*	1995
Australian Wood Duck	*Chenonetta jubata*	1999
Black Swan	*Cygnus atratus*	1990, 1999
Black-tailed Native-hen	*Gallinula ventralis*	1994
Black-winged Stilt	*Himantopus himantopus*	1992, 2006
Brown Treecreeper (s-e spp.)	*Climacteris picumnus victoriae*	Likely to occur (DSE, 2009)
Buff-banded Rail	*Gallirallus philippensis*	1994
Chestnut Teal	*Anas castanea*	1999
Clamorous Reed Warbler	*Acrocephalus stentoreus*	1994
Common Brushtail Possum	*Trichosurus vulpecula*	1982
Crested Pigeon	*Ocyphaps lophotes*	2000
Darter	*Anhinga melanogaster*	1994
Dusky Moorhen	*Gallinula tenebrosa*	2002
Eastern Great Egret	*Ardea modesta*	Likely to occur (DSE, 2009)
Eurasian Coot	*Fulica atra*	1988, 1989, 1991, 1992, 1993, 1994, 1998, 1999, 2000,
Freckled Duck	*Stictonetta naevosa*	1981, 1989, 1999,
Golden-headed Cisticola	*Cisticola exilis*	1982
Great Cormorant	*Phalacrocorax sulcriostris*	1994
Great Crested Grebe	*Podiceps cristatus*	1994
Great Egret	*Ardea alba/Ardea modesta*	1988, 1991, 1992, 1994, 1999
Growling Grass Frog	*Litoria raniformis*	1982
Hardhead	*Aythya australis*	1987, 1989, 1992, 1994, 1999
Hoary-headed Grebe	*Poliocephalus poliocephalus*	1994
Intermediate Egret	*Ardea intermedia*	1988, 1994
Little Grassbird	*Megalurus gramineus*	1994
Little Pied Cormorant	*Microcarbo melanoleucos*	1988, 1994
Masked Lapwing	*Vanellus miles*	1989
Musk Duck	*Biziura lobata*	1988, 1989, 1990, 1993, 1994, 1999
Pacific Black Duck	*Anas superciliosa*	1999
Pied Cormorant	*Phalacrocorax varius*	Likely to occur (DSE, 2009)
Pink-eared Duck	*Malacorhynchus membranaceus*	1999
Purple Swamphen	*Porphyrio porphyrio*	1982, 1990, 1994, 1996

Common name	Scientific name	Dates recorded
Red-knecked Avocet	*Recurvirostra novaehollandiae*	1982
Red-kneed Dotterel	*Erythrogonys cinctus*	1982
Royal Spoonbill	*Platalea regia*	1988, 1990, 1991, 1992, 1999, 2006
Sharp-tailed Sandpiper	*Calidris acuminata*	1979, 1999
Silver Gull	*Larus novaehollandiae*	1989
Straw-necked Ibis	*Threskiornis spinicollis*	1992, 1995
Superb Fairy-wren	*Malurus cyaneus*	1982
Swamp Harrier	*Circus approximans*	1995
Water Rat	*Hydromys chrysogaster*	1982
Whiskered Tern	*Chlidonias hybridus*	1988, 1989, 1989
White-bellied Sea-Eagle	*Haliaeetus leucogaster*	Likely to occur (DSE, 2009)
White-faced Heron	*Egretta novaehollandiae*	1999
White-necked Heron	*Ardea pacifica*	1999
White-striped Freetail Bat	*Tadarida australis*	1982
Yellow-billed Spoonbill	*Platalea flavipes*	1988
Fauna - Exotic		
Common Carp	**Cyprinus carpio*	1975, 1991
Goldfish	**Carassius auratus*	1981, 1991
Mosquitofish	**Gambusia holbrooki*	1989, 1990
Red Fox	**Vulpes vulpes*	1982
Redfin	**Perca fluviatilis*	1975, 1991
Tench	**Tinca tinca*	1991

Appendix E: Vegetation composition map – March 2009



Appendix F: Hydrology

Table F.1 Johnson Swamp water budget

Johnson Swamp water requirements		Area (Ha)	Depth (mm)	Period of inundation (days)	Wetland capacity - (ML)	Infiltration (ML)	Fill rate (ML/d)	Days to fill (days)	Evaporation (filling) (ML)	Evaporation (full wetland) (ML) (Table A#.5)	Volume required for water regime (ML)
	Year 1*	340	900	90	1783	255	100	20.4	139	1530	**2177**
	Year 1#	113	300	270	153		100	1.5	3	1322	**828**
	Year 2#	113	300	170	153		100	1.5	3	1220	**1067**
	Year 2#	**DRYING PHASE**									
	Year 3	**DRYING PHASE**									
	Year 4	**DRYING PHASE**									
	Year 5	**DRYING PHASE**									

****Please Note:** The calculations above are based on current information which will need to be reviewed in order to implement the recommended water regime (e.g. seasonal conditions will alter the hydrology of the swamp)

*Year1: Filling to occur in Winter Spring, although evaporation will occur the ecological objectives are targeting Lignum/Black Box which require 2-3 months inundation, therefore top ups are not required

#Year 1/Year 2: Targeting open water submerged aquatic assemblage for a duration of 18 months (265 ha)

Table F.2: Johnson Swamp water budget

			Inflows						**Outflows/Losses**					
Johnson Swamp water budget	**Water regime**	**Wetland capacity - (ML)**	**Rainfall - for period of inundation (mm) (Table A#.4)**	**Precipitation falling on wetland (ML)**	**Estimated catchment area (ha)**	**Local catchment runoff coefficient (ML/ha/year)**	**Surface water inflows (ML)**	**Total calculated inflows**	**Infiltration (ML)**	**Evaporation (filling) (ML)**	**Evaporation (full wetland) (ML) (Table A#.5)**	**Outflow/other losses (ML)**	**Total calculated outflows /losses**	**Volume required (ML)**
	Wet phase	1783	102.1	347.14	300	0.20	15	362	255	139		minor source	394	**1814**
		153	269.9	304.99	300	0.20	46	351			1322	minor source	1322	**630**
		153	175.8	198.65	300	0.20	30	229			1220	minor source	1220	**992**

*Inflows and outflows calculated on an average annual basis

*Surface Drainage and Groundwater inflow not quantified

Table F.3 Capacity Summary - Johnson Swamp

AHD Elevation (meters)	Volume (ML)	Surface Area (ha)	
77.4	0	21	Bed Level
77.5	36	51	
77.6	61	71	
77.7	153	113	Open water (30 cm)
77.8	314	209	
77.9	551	265	
78.0	828	289	
78.1	1,129	312	
78.2	1,449	329	
78.3	1,763	340	FSL

Figure F.1 Water Surface Area

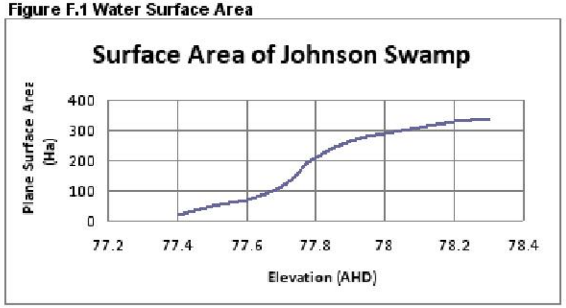


Figure F.2 Lake Johnson Capacity

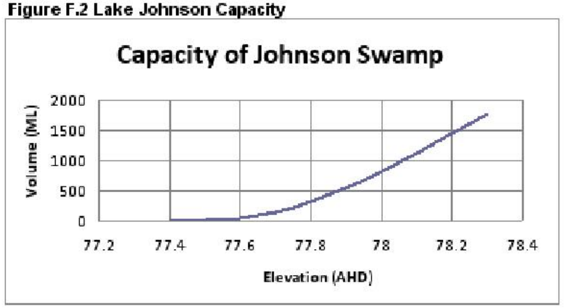


Table F.4 Climate Statistics (BOM, 2009)

Wetting Calender 18 months	Monthly Rainfall (mm)	Total rainfall	Evaporation rate (mm/day)
Sep	35.5		4
Oct	37.6		4
Nov	29	102.1	7
Dec	27.5		7
Jan	22.7		7
Feb	23.5		7
Mar	26.5		4
Apr	25.2		4
May	36.3		4
Jun	35.7		2
Jul	35.5		2
Aug	37	269.9	2
Sep	35.5		4
Oct	37.6		4
Nov	29		7
Dec	27.5		7
Jan	22.7		7
Feb	23.5	175.8	7
Total	547.8		

Table F.5 Evaporation Calculations

Name	Year	Area (ha)	Period of	Evaporation Rate (mm/d)	Evaporation (ML)	Total evaporation
Evaporation over wetting cycle	1	340	60	4	816	
	1	340	30	7	714	1530
	1	113	90	7	712	
	1	113	90	4	407	
	1	113	90	2	203	1322
	2	113	60	4	271	
	2	113	120	7	949	1220

Evaporation Rates	mm/day
Summer	7
Winter	2
Spring/Autumn	4

References:
Archard (2009) Review of Bathymetric Information for Johnson Swamp, Compiled by Dustin Chislett for the North Central CMA, Huntly
Bureau of Meteorology (2009) *Climate Statistics for Kerang, Australian Government, Canberra Date Accessed: 2 April 2009, URL: http://www.bom.gov.au/climate/averages/tables/cw_080023.shtml*
Goulburn Murray Water (2008) Environmental Water Allocations - Calculations for the SIRTEC, Agenda Paper Compiled by Sam Green and Mary Shi, Tatura
North Central CMA (2009) *NVIRP Technical Report: Wetland Watering Requirements,* Prepared for NVIRP, Shepparton
SKM (2001) *Johnson Swamp (West Side) Watering and Operational Plan,* Prepared for the North Central CMA, Huntly

Appendix G: Monitoring program recommendations

1. Long Term condition monitoring

Long term condition monitoring is recommended in order to evaluate any changes to wetland values over time. It should be noted that condition monitoring should be undertaken in conjunction with intervention monitoring to comprehensively evaluate any changes to Johnson Swamp.

Vegetation Condition and Distribution

A number of photo points have been established around Johnson Swamp (Appendix H) to enable the assessment of changes in wetland condition over time (Table G1). 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.

Table G1: Photo points for Johnson Swamp (GDA94 Zone 55)

Wetland	Photo ID	Easting	Northing	Facing
Johnson Swamp	JS Photo point 1	235108.5266	6032929.547	East
	JS Photo point 2	234592.0448	6032401.404	East
	JS Photo point 3	234283.1374	6031849.206	East
	JS Photo point 4	236233.7524	6031046.098	North west
	JS Photo point 5	235915.8035	6032108.068	West
	JS Photo point 6	235716.8795	6032169.946	West
	JS Photo point 7	235702.7889	6033101.558	West

It is also recommended that the condition and distribution of vegetation communities, including exotic species, throughout Johnson Swamp are assessed every five years. Information on vegetation communities gathered on aerial photography during this project has been digitised using GIS to enable comparison in distribution over time (distribution mapping) (MDBC 2005).

Additional methods that could also be employed in the evaluation of change to vegetation condition and distribution include:

- Index of Wetland Condition
- Habitat Hectares.

Groundwater Monitoring

Long term monitoring of groundwater within the immediate vicinity of Johnson Swamp is recommended to identify potential risks associated with watering the wetland and for consideration in adaptive management. DPI currently undertakes monthly groundwater monitoring at the wetland. It is recommended that this continues with particular regard to groundwater level and the potential for saline groundwater intrusion.

It is important that the monthly monitoring results are provided by DPI to the North Central CMA and the land manager to facilitate data analysis and inform adaptive management.

2. Intervention Monitoring

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

The results of each component of intervention monitoring will be used to reassess and amend the recommended flow regime as required.

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 G2. A database of any previous flora records has been compiled for Johnson Swamp and should be updated following regular monitoring.

Table G2: Components of vegetation intervention monitoring

Component	Target	Method	Objective
Vegetation distribution	Submerged aquatic vegetation, Lignum, Black Box, Cumbungi, Common Reed, Cane Grass	• Distribution mapping • Photo points •	Habitat objectives, species/community objectives
Vegetation condition	Lignum, Black Box, Cumbungi, Common Reed, Cane Grass	• Photo points •	1.2 – 1.4, 2.5
Species diversity	Additional species with a focus on submerged aquatics	• Species list comparison	1.1, , 2.2

Waterbirds

The diversity and abundance of waterbirds at Johnson Swamp needs to be monitored following watering in order to assess the success of implementation and achievement of objectives. Monthly monitoring as water levels fluctuate will ensure changes in bird communities are captured (MDBC, 2005). 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 Johnson Swamp and should be updated regularly following monitoring. Table G3 outlines the recommended components of waterbird monitoring.

Table G3: Components of intervention monitoring of waterbirds

Component	Target	Method	Objective
Species diversity	All species including those of conservation significance	• Area searches (MDBC 2005)	Habitat objectives, 2.1, 2.2
Waterbird abundance			Habitat objectives, 2.1, 2.2
Habitat availability	Open water, mudflat, tall marsh vegetation, Lignum and Black Box	• Undertaken in conjunction with vegetation monitoring	Habitat objectives, 2.1, 2.2
Breeding populations	White Ibis, Great-crested Grebe, Black Swan, Australian Shelduck, Pacific Black Duck, and Freckled Duck	• Nest surveys (MDBC 2005)	Habitat objectives, 2.1

Fish and Macroinvertebrates

It is recommended that the response of fish and macroinvertebrates is monitored following watering as they are sufficient 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 Johnson Swamp and should be updated regularly following monitoring. Table G4 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 G4: 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 (MDBC 2005) • Sweep netting/AusRivas • Call playback, funnel trapping, drift fences and pit traps (MDBC 2005)	2.3, 2.4
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 G5 identifies elements to be considered as part of the water quality monitoring program

Table G5: Components of intervention monitoring for water quality

<table>
<tr><th>Component</th><th>Target</th><th colspan="2">Method</th><th>Objective</th></tr>
<tr><td rowspan="5">Water quality</td><td>Electrical conductivity</td><td>Conductivity metre</td><td rowspan="4">Water quality meter</td><td rowspan="5">Habitat objectives, 2.1–2.4</td></tr>
<tr><td>pH</td><td>pH metre</td></tr>
<tr><td>Turbidity</td><td>Turbidity metre</td></tr>
<tr><td>Dissolved oxygen</td><td>Oxygen metre</td></tr>
<tr><td>Nutrients</td><td colspan="2">Laboratory analysis</td></tr>
</table>

Appendix H: Photo points

JS Photo point 1

JS Photo point 2

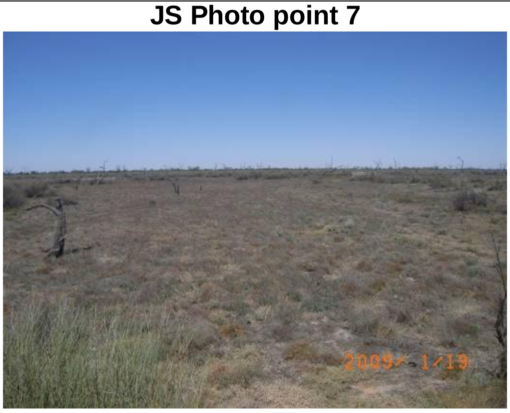
JS Photo point 3

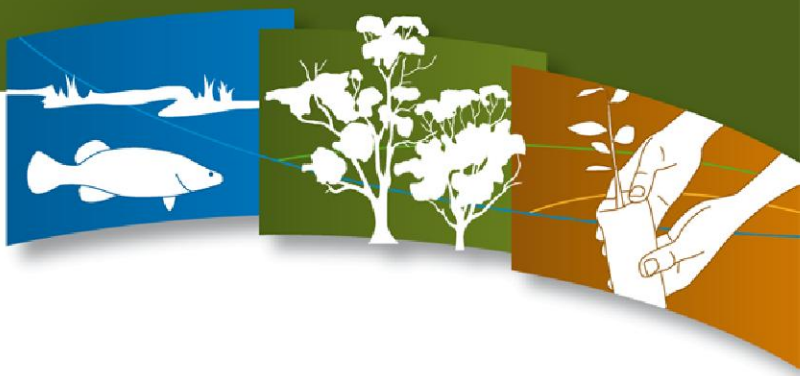
JS Photo point 4

JS Photo point 5

JS Photo point 6

JS Photo point 7





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