LAKE MURPHY

ENVIRONMENTAL WATERING PLAN

NORTH CENTRAL
Catchment Management Authority
Connecting Rivers, Landscapes, People

PREPARED FOR THE
NORTHERN VICTORIA IRRIGATION RENEWAL PROJECT

NVIRP

June 2010

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Front cover photo: Lake Murphy, March 2009, North Central CMA

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EXECUTIVE SUMMARY

The Lake Murphy Environmental Watering Plan (EWP) documents the approach to mitigating the potential impacts of the Northern Victoria Irrigation Renewal Project (NVIRP) due to the automation of the Torrumbarry 17/2 channel that outfalls into Lake Murphy.

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

Defining the environmental values of Lake Murphy

Lake Murphy is a Wildlife Reserve and classified as a deep freshwater marsh. It has a high conservation status due to its size, habitat diversity, prevalence of native vegetation and provides valuable habitat for aquatic fauna, e.g. it is highly productive for waterbirds which use the wetland for habitat and feeding.

Over the past 10 years, the combined effects of drought and increased efficiencies in the irrigation system have reduced the total volumes of outfall that the lake receives to zero. Lake Murphy is currently in a dry phase.

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

Lake Murphy water management goal

To provide a water regime that supports a diversity of waterbirds, flora and fauna typical of a deep freshwater marsh.

Defining the water required to protect the environmental values

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

Wetland water regime:

Fill Lake Murphy to approximately one metre deep two in five years and ensure inundation period of at least six months (may require top-ups if there is a waterbird breeding event).

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

The total volume required to fill the wetland is 2,905 ML. The maximum volume ever likely to be required over any 12 month period (95th percentile mean annual volume) is 3,245 ML.

Assessment of mitigation water requirement

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

The assessment of the requirements for mitigation water for Lake Murphy demonstrates that recorded outfalls provide no benefit to the wetland and therefore mitigation water for this baseline incidental water contribution is not required. However, **the leakage from the outfall structure provides benefits to the wetland and provision of mitigation water is warranted (if rationalisation of infrastructure or upgrading of the outfall structure occurs)**. The leakage will not be impacted unless there is a change to the infrastructure supplying the wetland. If the leakage of water was reduced or removed, additional water would need to be secured to provide annual flows to maintain the vegetation, which provides habitat for a variety of fauna species and enhances opportunities for recolonisation of Lake Murphy when filled.

The leakage through the drop board structure has not been quantified as it will not be impacted unless rationalisation or upgrade of the outfall structure occurs. If NVIRP actions are likely to impact on the leakage from the outfall structure, then quantification of the leakage and calculation of the mitigation water commitment will be required i.e. Step 4 (calculation of annualised baseline mitigation water volume), Step 5 (calculation of the mitigation water

commitment) and Step 6 (calculation of the Long-term Cap Equivalent Volume) will need to be completed.

The Mitigation Water Commitment for Lake Murphy is 0% of the baseline year incidental water at the origin (outfall regulating structure) because NVIRP has no impact in the immediate term on the incidental water received by the wetland.

Potential risks and adverse impacts associated with the recommended watering regime

A number of potential risks, limiting factors and adverse impacts have been identified that may result from the provision of mitigation water as a portion of the desired water regime. For example, salinity levels in the wetland bed (through an accumulation of salt) may impact on the ability for plants to recolonise in the future, particularly in Lake Murphy West.

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 Lake Murphy outfall structure has a delivery capacity of 70 ML/day which equates to a minimum of 30 days to fill the wetland. However, a willow blockage in the outfall channel is restricting this capacity.

The backbone channel associated with Lake Murphy is the Torrumbarry 17/2 channel which will be automated as far as the 3/17/2 channel offtake, approximately 1.4 km upstream of the Lake Murphy outfall structure.

Channel 3/17/2, on which the Lake Murphy outfall structure is located, is not part of the automated backbone and may be rationalised as part of the NVIRP Connections Program. However, it is recommended that the Lake Murphy outfall structure is not upgraded so that the leakage from the channel is maintained. If upgrades or rationalisation are scheduled either to the outfall structure or the 17/2 channel, the volume of leakage should be quantified and assessed through the mitigation water calculation process.

The 3/17/2 channel may need to be retained to supply water to Lake Murphy or alternative supply arrangements sought.

Adaptive management framework

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

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

Governance arrangements

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

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ACKNOWLEDGEMENTS

The information contained in the Lake Murphy Environmental Watering Plan (EWP) has been sourced from a variety of reports, field inspections, Wetland workshop, peer review and from individual knowledge and expertise.

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

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- Mark Tscharke, (Parks Victoria)
- Ross Plunkett, Chris Solum and Paul Lacy (NVIRP)
- NVIRP Technical Advisory Committee (listed in Appendix A, Table A1)
- Wetland workshop attendees (listed in Appendix A, Table A2)
- John Murphy, Barry Baulch, Alan Marshal (Landholders)
- Chris Coleborn (Birds Australia Member)
- Peer Review: Brett Lane (Brett Lane & Associates), Terry Hillman (Hillman *et al*.) and Peter Alexander (Hydro Environmental)
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ABBREVIATIONS

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

1. Northern Victoria Irrigation Renewal Project

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

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

1.1 Decision under the *Environmental Effects Act 1978*

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

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

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

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

1.2 Water Change Management Framework

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

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

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

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

The 10 wetlands are:

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

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

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

1.3 Purpose and scope of Environmental Watering Plans

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

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

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

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

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

1.4 Development process

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

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

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

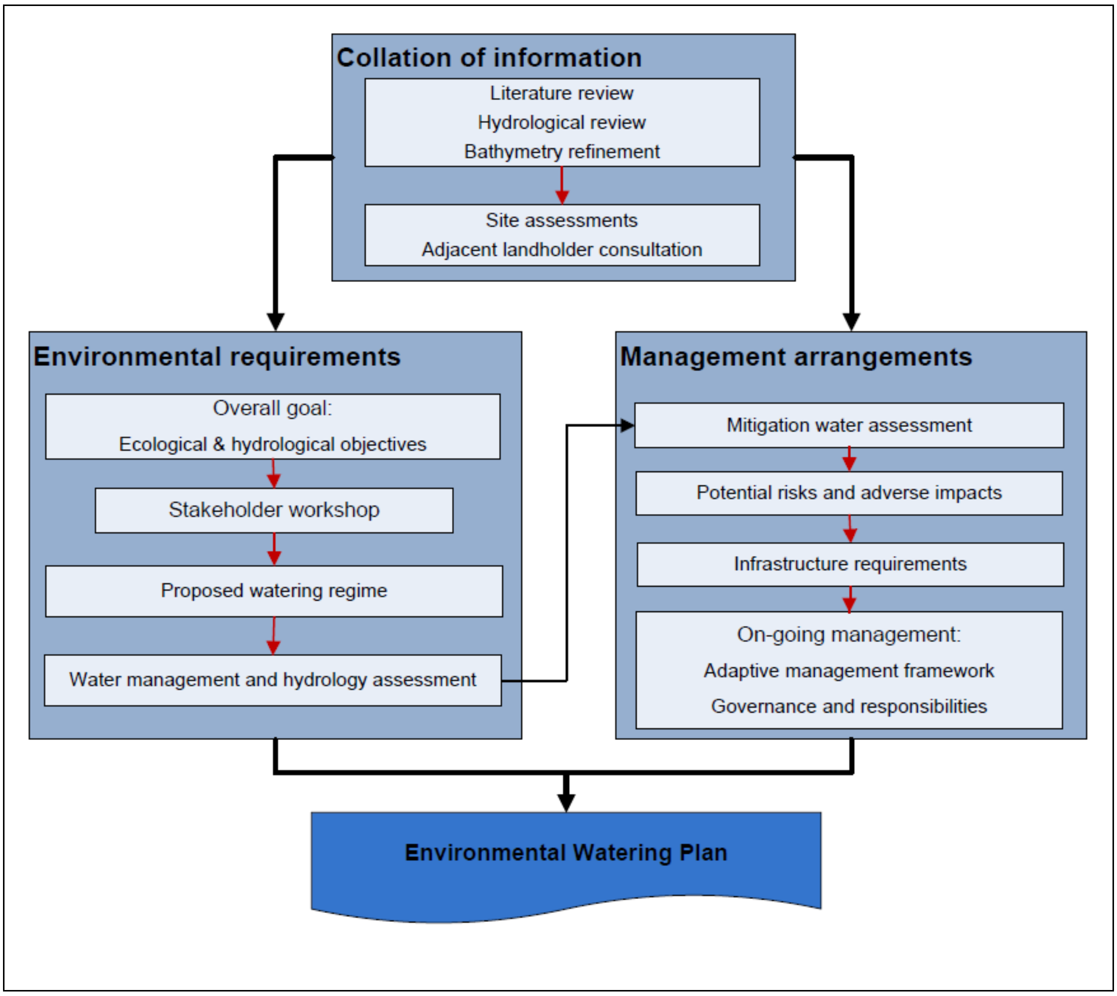

Figure 1: EWP development process

1.4.1 Consultation and engagement

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

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

A workshop was held on 19 March 2009 with key agency stakeholders and technical experts (Appendix A) in order to discuss and refine the water management goal, ecological objectives, and water requirements for Lake Murphy.

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. Lake Murphy

Lake Murphy is a 168 ha intermittent wetland situated approximately 8 km south-west of Kerang, Victoria (Figure 2). It is located within the Wandella Creek sub-catchment of the Loddon river basin and is listed as being of bioregional significance. Lake Murphy supports a significant diversity and abundance of invertebrates, waterbirds and other flora and fauna species when flooded.

Although Lake Murphy is a single lake, the presence of a narrow, slightly elevated section effectively separates the lake into two and these separate sections are referred to as Lake Murphy East and Lake Murphy West (Figure 4 below). Lake Murphy East is smaller and deeper than Lake Murphy West and is generally less saline (approximately 400 EC compared to 1000 EC), therefore providing different habitat values. Lake Murphy at full supply level (78.0 m AHD) is 1 to 1.5m deep with a storage capacity of approximately 2,000 ML.

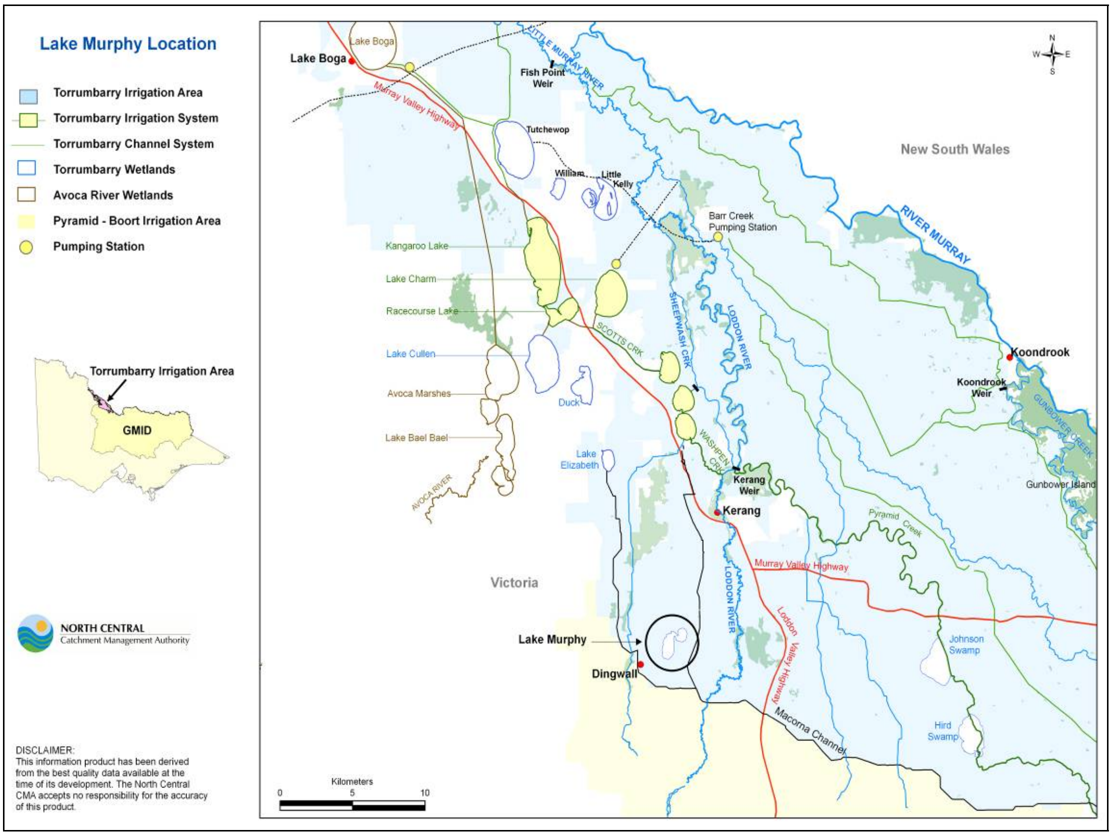

Figure 2: Location of Lake Murphy

2.1 Wetland context and current condition

Prior to European settlement, Lake Murphy was a shallow freshwater marsh (DSE 2009a). A change to the hydrology of the area, most notably the development of the Torrumbarry Irrigation System in the 1920s, has resulted in a shift in classification to that of a deep freshwater marsh dominated by reed vegetation and dead Black Box (DCFL 1989; Lugg, Heron, Fleming and O'Donnell 1989; DSE 2009b). Deep freshwater marshes remain flooded for most of the year but may dry out occasionally.

The environmental values of Lake Murphy have been impacted by the current dry phase (2005–06); with water dependent species reducing in abundance and showing signs of stress (e.g. Cumbungi and Tangled Lignum). Appendix E illustrates the generic vegetation composition of Lake Murphy surveyed in March 2009. The following is noted:

- Lake Murphy East is dominated by reed vegetation which is being maintained via the small leakage at the outfall
- Lake Murphy West is dominated by dead Black Box
- Sporadic occurrences of Tangled Lignum observed around the southern and western margin, although considered to be stressed
- Older Black Box trees are in poor health

- There is high weed cover (~75%) of Athel Pine, Spiny Rush, Sea barley Grass, Water Couch (introduced) and Prickly Lettuce (mostly annuals).

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

2.2 Catchment setting

Lake Murphy is situated within the Wandella Creek sub-catchment of the Loddon river basin in the Victorian Riverina bioregion. The wetland has a small local catchment area of approximately 1,600 ha and is encircled by an extensive agricultural landscape consisting primarily of broadacre dryland cropping and grazing (Davies *et al.* 2005).

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

Lake Murphy has been disconnected from the Loddon River floodplain by levees and channels and receives the majority of its water via the G-MW 3/17/2 channel located to the north of the wetland. Some drainage water from nearby farming properties also outfalls to the wetland (Figure 3) (SKM 1997).

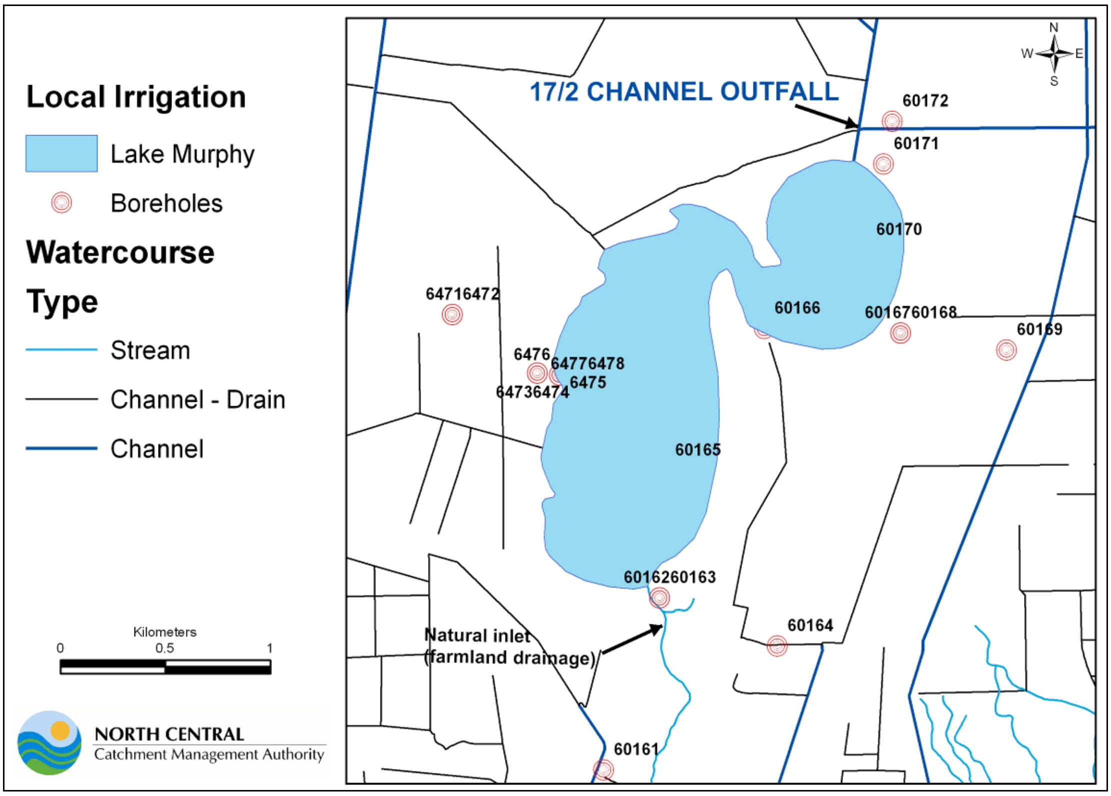

Figure 3: Inflow points at Lake Murphy

2.3 Land status and management

Lake Murphy 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. Lake Murphy will remain part of a Wildlife Reserve under the “state game reserve” classification. These reserves will be managed to conserve and protect species, communities or habitats of indigenous animals and plants while permitting the use for recreational (including hunting in season as specified by the land manager) and educational purposes (DSE 2009c; VEAC 2008).

2.4 Cultural heritage

The Kerang Lakes area is recognised as an important cultural heritage and archaeological region in Victoria. Lake Murphy is an area of cultural heritage sensitivity (DPCD 2008). Several sites such as middens, mounds and scatters are present especially on the eastern perimeter of the wetland and site protection works have been undertaken (fencing at selected sites).

2.5 Recreation

Lake Murphy has been identified 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).

2.6 Legislative and policy framework

2.6.1 International agreements

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).

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

2.6.2 Federal legislation

The *Environment Protection and Biodiversity Conservation (EPBC) Act 1999* is the key piece of legislation pertaining to biodiversity conservation within Australia. It aims to control potential impacts on matters of national environmental significance (MNES)[1].

Lake Murphy is known to support protected migratory waterbirds. The wetland is also known to support Chariot Wheels (*Maireana cheelii*), a flora species listed under the *EPBC Act* (Table 1 and Table 2) (DSE 2005). Actions that may impact on any of these MNES are subject to assessment and approval by the Minister for the Environment, Heritage and the Arts. The NVIRP works program is also subject to assessment and approval under the *EPBC Act*.

2.6.3 State legislation

Flora and Fauna Guarantee Act (FFG) 1988

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

Environmental Effects Act 1978

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

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

any associated environmental impacts are subject to assessment and approval under the Act (as discussed in Section 1.1).

Planning and Environment Act 1987

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

Water Act 1989

The *Water Act 1989* is the legislation that governs the way water entitlements are issued and allocated in Victoria. The Act also identifies water that is to be kept for the environment as part of the Environmental Water Reserve. The Act therefore 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 (DPCD 2007). Lake Murphy is known to support places of cultural significance (Section 2.4).

Other - Threatened Species Advisory Lists

Threatened species advisory lists for Victoria are maintained by the DSE and are based on technical information and advice obtained from a range of experts which are reviewed every one to two years. These advisory lists are not the same as the Threatened List established under the *FFG Act*. However, some of the species in these advisory lists are also listed as threatened under the *FFG Act*. Lake Murphy is known to support flora and fauna species that are included on the advisory list (Table 1 and Table 3).

3. Lake Murphy environmental values

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

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

Lake Murphy is known to support a range of environmental values and has a high conservation status due to its size, habitat diversity, prevalence of native vegetation and waterbird carrying capacity (SKM 1997).

3.1 Fauna

The wetland is semi-degraded, particularly the western lake area. However, deliveries of environmental water in recent years has enhanced the conservation value of the wetland and provided valuable habitat for aquatic fauna, including waterbirds and macroinvertebrates (Reid and O'Brien 2009). Lake Murphy has proved to be extremely productive for waterbirds with surveys in 2002 noting in excess of 3,800 birds using the wetland for habitat and feeding (DSE 2004).

Over twenty-eight waterbird species have been recorded at Lake Murphy, including species protected by international agreements (JAMBA/CAMBA/ROKAMBA/Bonn), national (*EPBC Act*) and state (*FFG Act*) legislation. The wetland provides important habitat for the endangered Freckled Duck (*Stictonetta naevosa)* and Blue-billed Duck (*Oxyura australis)* (Table 1 and Appendix D).

Table 1: Significant species recorded at Lake Murphy

Common name	Scientific name	International agreements	EPBC listing	FFG listing	DSE listing
Australasian Shoveler	*Anas rhynchotis*				VU
Bar-tailed Godwit	*Limosa lapponica*	J / C / R / B			
Blue-billed Duck	*Oxyura australis*			L	EN
Brolga	*Grus rubicunda*			L	v
Caspian Tern	*Sterna caspia*	J / C		L	NT
Common Greenshank	*Tringa nebularia*	J / C / R / B			
Curlew Sandpiper	*Calidris ferrginea*	J / C / R / B			
Eastern Great Egret	*Ardea modesta*	J / C			
Freckled Duck	*Stictonetta naevosa*			L	EN
Glossy Ibis	*Plegadis falcinellus*	C / B			NT
Great Egret	*Ardea alba*	J / C		L	VU
Hardhead	*Aythya australis*				VU
Little Egret	*Egretta garzetta*			L	EN
Marsh Sandpiper	*Tringa stagnatilis*	J / C / R / B			
Musk Duck	*Biziura lobata*				VU
Pied Cormorant	*Phalacrocorax varius*				NT
Red-necked Stint	*Calidris ruficollis*	J / C / R / B			
Royal Spoonbill	*Platalea regia*				VU
Sharp-tailed Sandpiper	*Calidris acuminata*	J / C / R / B			
Whiskered Tern	*Chlidonias hybridus*				NT
White-bellied Sea-	*Haliaeetus leucogaster*	C		L	VU

Common name	Scientific name	International agreements	EPBC listing	FFG listing	DSE listing
Eagle					
Wood Sandpiper	*Tringa glareola*	J / C / R / B			VU

Conservation Status:
- J/C/R/B: JAMBA/CAMBA/ROKAMBA/Bonn International agreements listed in section 2.4.1
- FFG listing: L – Listed as threatened
- DSE listing: EN – Endangered, VU – Vulnerable, NT – Near Threatened

3.2 Flora

Pre-1750 DSE ecological vegetation class (EVC) mapping describes vegetation within Lake Murphy prior to European settlement as Lignum Swampy Woodland (EVC 823) surrounded by chenopod woodland vegetation. Recent EVC mapping (DSE 2005) suggests that Lake Murphy remains a Lignum Swampy Woodland, surrounded by Chenopod Grassland (EVC 829) vegetation. A small area of Semi-arid Chenopod Woodland (EVC 98) is also located between the wetland and Murphy's Lake Road to the east. The current EVCs and bioregional conservation status for Lake Murphy are presented in Table 2.

Table 2: Lake Murphy EVCs

EVC No.	EVC	Bioregional Conservation Status[1]
823	Lignum swampy woodland	Vulnerable
829	Chenopod grassland	Endangered
98	Semi-arid chenopod woodland	Endangered

Note 1: Within Victorian Riverina Bioregion.

According to the state-wide Flora Information System (FIS) database four flora species of conservation significance have been recorded at Lake Murphy (Table 3 and Appendix D). Cane Grass and Spiny Lignum have been listed by VEAC (2008) as flood-dependant .

Table 3: Significant flora species recorded at Lake Murphy

Common name	Scientific name	EPBC listing	FFG listing	DSE listing
Cane Grass	*Eragrostis australasica*			VU
Chariot Wheels	*Maireana cheelii*	VU		VU
Spiny Lignum	*Muehlenbeckia horrida*			DD
Woolly Buttons	*Leiocarpa panaetioides*		P	

Conservation Status:
- EPBC listing: VU - Vulnerable
- FFG listing: P - Protected
- DSE listing: VU – Vulnerable, DD – Data Deficient

3.3 Representativeness and distinctiveness

Lake Murphy is classified as a deep freshwater marsh (DSE 2009e). The deep freshwater marsh is one of the most depleted wetland categories within Victoria. Deep freshwater marshes are often drained to facilitate agricultural activities including grazing or cropping, and have subsequently decreased in extent across the landscape. The area of deep freshwater marshes across Victoria is estimated to have decreased by approximately 70% since European settlement (DNRE 1997). Table 4 illustrates the area of deep freshwater marshes across various defined landscapes and the proportion of which is occupied by Lake Murphy.

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

	North Central region	GMID	Victorian Riverina	Victoria
Deep freshwater marsh (ha[1])	4,880	7,296	6,364	54,886
Lake Murphy (168ha)	3.5%	2.5%	3%	<1%

Note 1: Areas calculated from DSE 2009g

Lake Murphy occupies 168 hectares which is 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).

Lake Murphy is distinctive because it supports the following characteristics:

- Supports threatened flora and fauna species (Section 3.1.1 and Appendix D)
- Supports breeding populations of waterbirds including Purple Swamphen (*Porphyrio porphyrio*), Hoary Headed Grebe (*Poliocephalus poliocephalus*), Black Swan (*Cygnus atratus*) and Australian Shelduck (*Tadorna tadornaoides*)
- Provides important habitat for the Freckled Duck (*Stictonetta naevosa).*

4. Hydrology

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

4.1 Natural water regime

Lake Murphy is located with the Wandella Creek sub-catchment in the Loddon River basin. The wetland's natural water supply originated from floods in the Loddon River and Wandella Creek. In large flood events, the wetland would have overflowed in a north-westerly direction towards Wandella Forest. It is estimated that Lake Murphy historically received up to 30% of the Loddon River floodwater. Disconnection from the floodplain has significantly reduced the floodwaters that the wetland now receives (SKM 1997).

The natural hydrological cycle of Lake Murphy would have consisted of flooding in winter and spring, with drawdown due to evaporation occurring over the summer months (SKM 1997). Periodic flushing would have enabled the export of salt out of the wetland assisting in the maintenance of salinity levels. The fluctuating water levels would have supported a diversity of flora (aquatic and terrestrial) and fauna (Rob O'Brien, DPI, pers. comm. 2009). Under natural conditions, Lake Murphy was probably dry most of the time and the small diameter of Black Box stumps within the wetland are a reflection of the regular inundation of the wetland coupled with salinity levels which are unfavourable to this species (SKM 1997).

Although Lake Murphy is a single wetland, the presence of the narrow, slightly elevated section effectively separates it into two, Lake Murphy East and Lake Murphy West (Figure 4). Lake Murphy East is smaller and deeper than Lake Murphy West and is generally fresher (approximately 400 EC compared to 1000 EC), therefore providing different habitat values (SKM 1997).

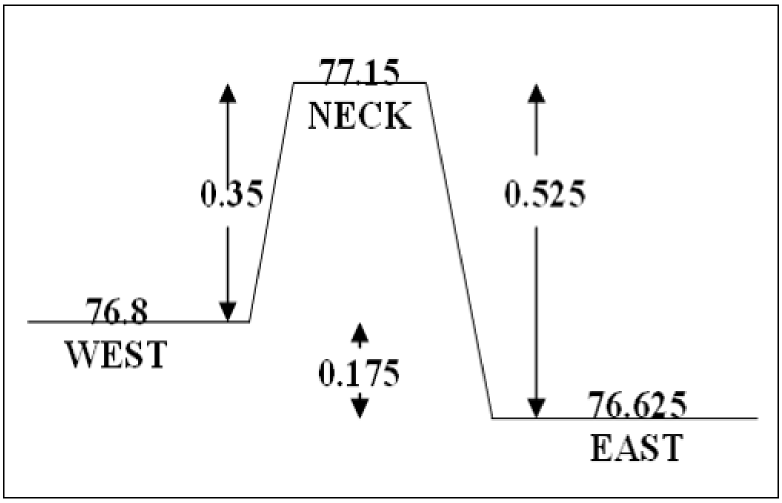

Figure 4: Lake Murphy cross section (SKM 1997)

4.2 History of water management

Historically, Lake Murphy was used as a freshwater irrigation storage which enabled flushing of water through the wetland and increased its permanency. Water was diverted from the Loddon River and pumped from Lake Murphy into a 'trust' channel, through Wandella Forest to Lake Elizabeth. In the early 1900s this practice ceased, and Lake Murphy became a terminal system. As a consequence of limited through-flow and the significant increase in district saline groundwater levels, Lake Murphy began to accumulate salt.

Lake Murphy has historically received outfalls from the 17/2 channel system from rainfall rejection events occurring after heavy rains, and surplus flows. Although not recorded, these may have been as high as 10-12 ML/day (Greg Turner, DPI, pers. comm. in SKM 1997). Anecdotal information suggests that prior to the 1990s water bailiffs would intentionally outfall water prior to the opening of the duck season. The periodic flushing and flooding conditions would have provided suitable open water and mudflat habitat for waterbirds (Plate 2) (O'Brien 2009).

Since the 1990s due to system upgrades and increased efficiencies, outfall water to Lake Murphy has been significantly reduced and waterbird habitat has largely been maintained through the provision of environmental water (Figure 5).

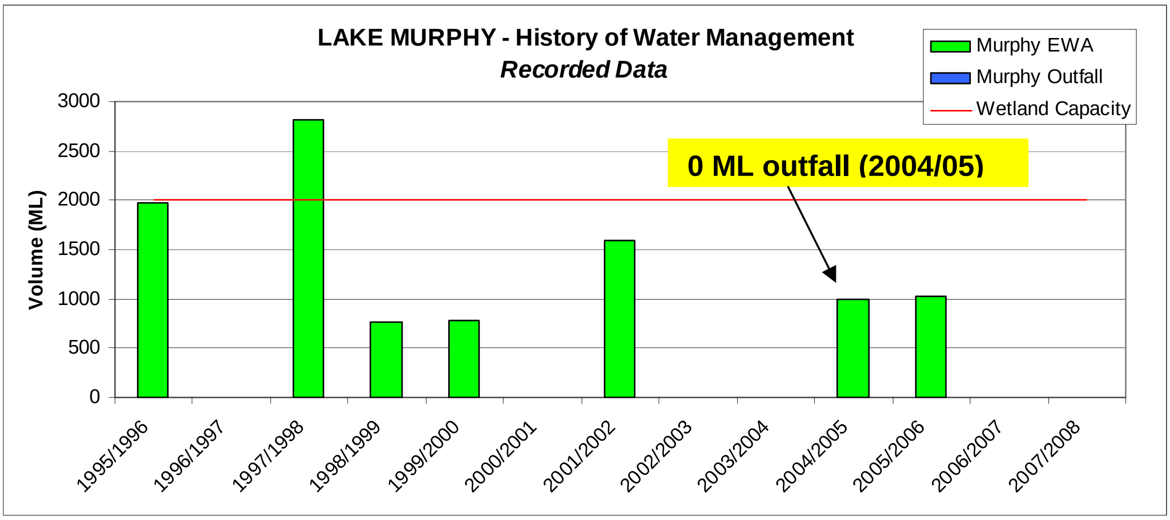

Figure 5: Recorded volumes received by Lake Murphy from 1995 to 2008 *Note: No outfalls have been recorded for Lake Murphy since recording began in 1998*

Over the past 10- 15 years, environmental water has regularly been allocated to Lake Murphy from the Murray Flora and Fauna Bulk Entitlement to provide conditions for waterbird feeding and breeding. The cycle of wetting and drying and relative water sources is shown in Table 5.

Table 5: Lake Murphy wetting/drying calendar (Source: DSE 2008b).

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
Wetting/Drying cycle[1]	w?	d	w	w	w	d	w	d	d	w	d	w	w	d	d

Note 1: w – water present, d – wetland dry

Plate 1: Dry phase (March 2009)

Plate 2: Wet phase (1985)

4.2.1 Recorded outfalls and NVIRP

The baseline water year, 2004-2005, has been selected to quantify the savings as part of water savings projects (DSE 2009g). The comparison of estimated water savings with a baseline year is necessary to convert the savings to water entitlements and ensure that there are no impacts on service delivery or reliability for existing entitlement holders (DSE 2008). 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.

Outfall data for Lake Murphy has been recorded by G-MW since 1998 (Figure 5). Records indicate that there have been no outfalls to the wetland between 1998 and 2008. Anecdotal information as noted above, suggests that prior to the 1990s outfall volumes were significant. However, due to a combination of increased channel efficiency, lower water allocations and the perceived adverse impacts of outfalls on the wetland (increasing salinity levels), these have ceased.

Although there are no recorded outfalls for Lake Murphy, there is significant leakage from the outfall structure to the wetland. This leakage has not been quantified and is not recorded. Currently, the water is supporting a confined area of vegetation at the inlet channel in Lake Murphy East.

4.3 Surface water/groundwater interactions

DPI has monitored surface water at Lake Murphy since 1990 and the groundwater since 1994, on a monthly basis. In September 1999, additional surface water and groundwater monitoring sites were established to obtain more comprehensive data on the wetland.

The regional groundwater flow is in a general northerly direction. This pattern is complicated from time to time by local seasonal influences from streams, channels and wetlands. The hydraulic gradient is quite flat across the area and especially so at present, as evidenced by the latest groundwater hydrograph data (Reid and O'Brien 2009).

Groundwater levels are presently at their lowest on record (as at July 2008) and are at similar elevations (approximately 75.5 to 75.8 m AHD) around the wetland, the notable exception being Bore 60172, which is located right next to the 17/2 channel outfall (Figure 3) and most likely responding to leakage.

The hydrograph record shows a history of dynamic groundwater behaviour with watertable levels in the vicinity of Lake Murphy corresponding well to wetland levels. The most recent filling was in 2006. Since then, the wetland has been allowed to completely dry and watertables under and surrounding the wetland have dropped by between about one and two metres (Figure 6).

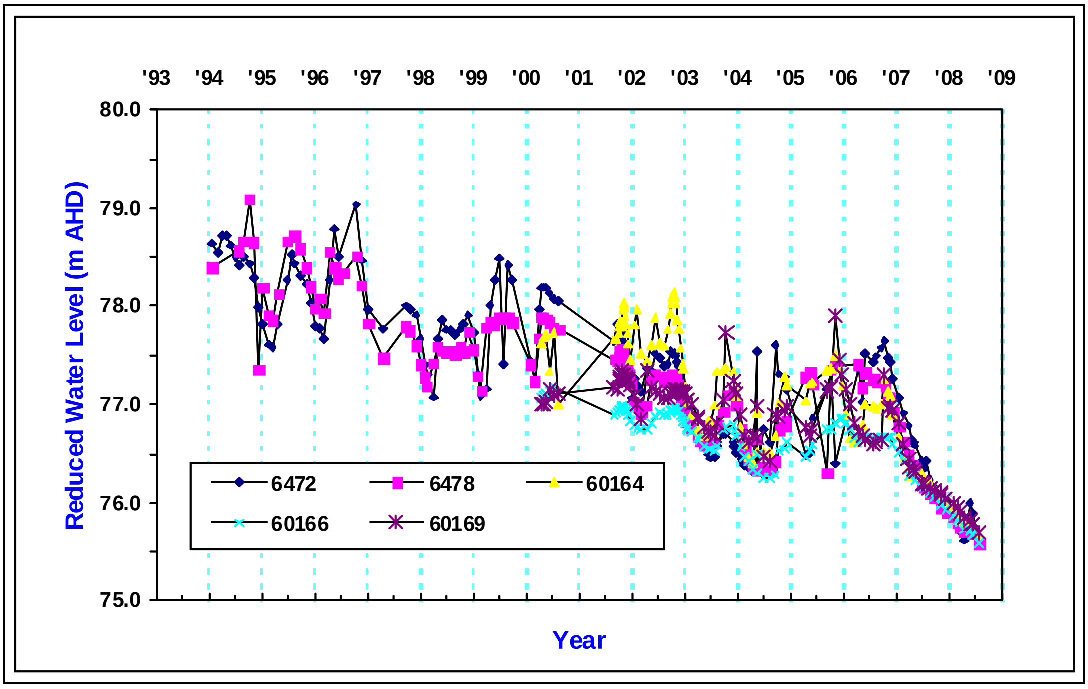

Figure 6: Hydrograph showing the changing watertable elevations at Lake Murphy

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

- Present watertable levels reflect the regional watertable surface (no obvious lake overprint), with the exception of Bore 60172, located next to the channel outfall
- There is presently only a low salinity risk to the wetland area
- The watertable depth during lake-dry periods, especially now, are sufficiently low to provide good leaching potential
- It is quite safe and appropriate for the wetland to be filled at levels consistent with the watering regime of 1999 to 2006.

It is expected that subsequent environmental water delivery to Lake Murphy will have some temporary impact on the watertable locally and assist in moving salt away from the wetland without causing significant risk to adjacent areas, especially if surrounding watertables remain relatively low as they have for the last 12 years.

From the information sourced, it is concluded that if Lake Murphy is left in a dry (or predominantly dry/low-level) state, the western wetland area will retain relatively high salt levels without sufficient water to flush it into the groundwater system, and hence will tend to be dominated by salt-tolerant plant species. 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. However, some additional threat to it (i.e. the western lake area), if maintained in a dry/low-level state, could arise periodically from increased groundwater heads to the south or south-east generated by episodic flooding of the Loddon River floodplain.

Source: Reid and O'Brien 2009

4.4 Surface water balance

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

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

A surface water balance and associated calculations to define the hydrological characteristics of Lake Murphy 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 required for the proposed water regime (Section 5.3).

The main components of the model are outlined below:

- **Time Series:** the daily time step is set up to run from May 1891 to end of 2009.
- **Wetland capacity:** volume required to fill the wetland to the targeted supply level, i.e. FSL (78.0 m AHD).
- **Infiltration:** volume required to fill the underlying soil profile. Calculation of this volume has been adapted from measurements undertaken by G-MW (G-MW 2008a). The following assumptions were included in the application of the SWET model for Lake Murphy (Gippel 2005a, Gippel 2005b, Gippel 2005c):
    - Infiltration (ML) = Soil cracking (%) x area of wetland (ha) x depth (mm))/100
    - Soil cracking – 25% of surface area
    - Average depth of 300mm
    - Ongoing losses via infiltration are considered negligible due to the low permeability of the underlying soil (G-MW 2008b)
- **Rainfall/runoff:** this includes rainfall directly falling onto the wetland and surface run-off. Surface water inflows/run-off: an average volumetric figure of 0.2 ML/ha/year for the Kerang area (DPI and HydroEnvironmental 2007).
- **Climate data:** SILO DataDrill including wind data (Bureau of Meteorology)
- **Evaporation data:** a modelled approach (combination of the Penman-Monteith method with a deBruin adjustment; recommended by the CSIRO) to assessing evaporation at the wetland has been incorporated into the water balance (McJannet *et al*.2009).

Please note:

- *Groundwater is not included in the model (Gippel 2010). While groundwater may contribute in some circumstances it is not readily quantifiable or not easily factored into the model.*
- *The modelling does not consider water diversion/extraction from Lake Murphy as part of the overall surface water balance.*
- *The model has been set up so as to manage water levels at a single target level (79.1 m AHD). Therefore, it is not possible model fluctuating water levels (different target levels) overtime in order to test various management scenarios.*

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

4.5 Operational uses

Lake Murphy is now a terminal system filled by rainfall, channel outfalls from the G-MW 3/17/2 channel (leakage or environmental water), drainage and surface run-off. The natural flooding of Lake Murphy from Wandella Creek is prevented by levees and drainage.

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

Over-topping and leakage through and around the outfall structure to the wetland occurs regularly during the irrigation season (October to May).

4.5.1 Drainage

Lake Murphy has a local catchment area of approximately 1,600 ha (SKM 1997). Surface run-off from the surrounding land has not been monitored but it was considered to be significant, especially in the wetter periods of the early 1970s to mid 1990s. Over the past 12 years the volume of local catchment runoff has reduced significantly due to the reduction in rainfall and rainfall intensity combined with a drier catchment. Minor drainage flows enter from small depressions that flow into Lake Murphy West at various points along the western bank.

Local catchment runoff entering the wetland could have positive environmental benefits. However, this is dependent on the timing of the runoff and the water quality. During wetter periods i.e. 1980s and mid 1990s, the local drainage inputs were often viewed as having a negative impact on the environmental values of the wetland (increased nutrient and salinity inputs) (Rob O'Brien, DPI, pers. comm. 2009)

5. Management objectives

Lake Murphy has previously been managed as a deep freshwater marsh with the objective of providing habitat for a number of common and rare bird species (Table 1 and Appendix D). It is an extremely productive wetland especially as a waterbird feeding and breeding site. Table 6 provides an outline of information and management recommendations from previous Lake Murphy reports.

Table 6: Previous management recommendations for Lake Murphy

Source	Wetland Type	Objectives	Dur	Timing	Freq[1]	Quality (EC)
Lugg *et al.*, 1989	Deep Freshwater Marsh	• Water bird feeding and breeding • Critical biota areas (*Ruppia*, Cumbungi, sago/pondweed)	8-9 months (1 in 4)	Winter/ spring	3 in 4	In wetland <4,000EC Inflow <500EC
SKM, 1997	Deep Freshwater Marsh	• Native Vegetation • Waterbirds carrying capacity • Salinity (primary objective) • Reduction in spread of *Typha*	n/a	Aug-Sept	3 in 4	n/a

Note 1: Frequency of filling is filling the wetland three years in four.

5.1 Water management goal

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

Lake Murphy water management goal
To provide a water regime that supports a diversity of waterbirds, flora and fauna typical of a deep freshwater marsh.

The water management goal for Lake Murphy recommends managing the wetland as a deep freshwater marsh which reflects previous management recommendations. 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 water regime needed to support the values in the long-term (i.e. ensuring viability of species and habitats into the future).

5.2 Ecological objectives and hydrological requirements

Ecological objectives and hydrological requirements have been identified in determining a desired water regime to support high environmental values in Lake Murphy (Table 7). The process for identifying ecological and hydrological objectives closely follows that recommended in FLOWs: a method for determining environmental flow requirements in Victoria (DNRE 2002). The ecological objectives outline the outcomes desired from delivery of the desired water regime.

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

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

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

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

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

Hydrological requirements describe the water regimes required for achieving ecological outcomes (ecological objectives) (DNRE 2002). All values identified have components of their life-cycle or process that are dependent on particular water regimes for success e.g. colonially breeding waterbirds require certain timing, duration and frequency of flooding to successfully breed and maintain their population. Requirements for the three characteristics of a water regime[2] were identified and described for all of the ecological values.

Source: Campbell, Cooling & Hogan 2005

The ecological objectives and hydrological requirements for Lake Murphy were developed in conjunction with agency stakeholders and technical experts presented at the wetland workshop held in March 2009.

Table 7: Lake Murphy ecological objectives and hydrological requirements

Ecological objective	Justification	Hydrological requirement
1. Habitat objectives		
1.1.1 Maintain assemblage of emergent aquatic community (Cumbungi, rushes and sedges)	The area of aquatic macrophytes at the outfall appears to filter the water and add biological activity to the rest of the lake.	Maintain confined community at outfall by providing a pulsed flow regime over the October/April Period (*this will need to be adaptively managed*).
1.1.2 Restore Lignum vegetation	Habitat for waterbirds that favour tall, dense reed vegetation (e.g. Freckled Duck and Whiskered Tern).	Restore Lignum community by providing short duration flooding for 2-3 months for 1 in 3 to 1 in 7 years.
1.1.3 Restore existence/health of Black Box trees • Provide opportunities for recolonisation of trees	Black Box trees provide hollows, fallen branches and cover (nesting and roost for birds).	Re-establish Black Box by providing periodic short duration flooding for 2-3 months for 1 in 3 to 1 in 7 years. • Timing: Winter/ early Spring (critical to salinity management).
1.2.1 Restore open water, dead standing timber associated mudflat habitat.	Open water and mudflat habitat for waterbirds (e.g. Musk Duck, Royal Spoonbill, Sharp-tailed Sandpiper and Whiskered Tern)	Inundate this habitat by filling to FSL 2 in 5 years for six months • Timing: August/September
1.2.2 Restore Lignum vegetation	Habitat for waterbirds that favour tall, dense reed vegetation (e.g. Freckled Duck and Whiskered Tern).	Restore Lignum community by providing short duration flooding for 2-3 months for 1 in 3 to in 7 years.
1.2.3 Restore and maintain Chenopod community	Results in high biological activity (nutrient releases).	Ensure variability in water levels.
2. Species/community objectives		
2.1 Restore breeding of waterbirds	Swans, coots and ducks have previously bred at Lake Murphy.	Re-establish breeding events by filling wetland for a minimum of six months • Timing is not critical • Top ups may be required to extend duration
2.2 Restore feeding opportunities (food source) for water birds 2.3 Restore invertebrate population	To continue to provide the high waterbird carrying capacity (large numbers of Freckled Duck, Brolga, Sharp-tailed Sandpiper and Red-capped Dotterels previously recorded) Linked with habitat objectives – wetland and dryland flora, shallow water, mudflats and waters edge.	Inundate habitat (vegetation, shallow water and mudflats) by filling to FSL 2 in 5 years for a minimum period of six months.

[2] Timing, frequency and duration

Ecological objective	Justification	Hydrological requirement
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

5.3 Desired water regime

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

A schematic is provided to illustrate the various components of the wetland (e.g. Black Box/Lignum community and mudflats) that are being targeted by the watering regime (Figure 7).

Timing: Winter or spring filling (August to September)

Frequency of wetting: Minimum: one in four or one in five years

Optimum: two in five years

Maximum: one in two years

Duration: 6 months

Extent and depth: 1.1 metres

- Lake Murphy East (pulsed events)
- FSL to inundate both Lake Murphy East and West

Variability: Moderate (different objectives for Lake Murphy East and Lake Murphy West)

Wetland water regime:
Fill wetland to approximately one metre deep two in five years and ensure inundation period of at least six months (may require top-ups if there is a waterbird breeding event).

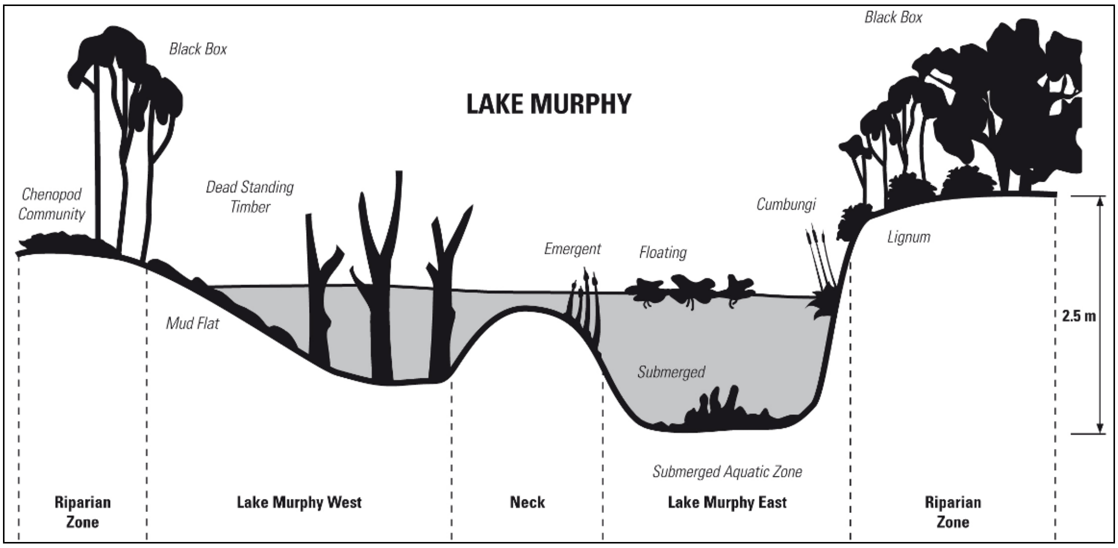

Figure 7: Schematic of wetland areas to be targeted (not to scale)

The volumes of water required to provide the desired water regime for Lake Murphy are presented in Table 8. These volumes reflect the results from the SWET modelling (Table 8 and Appendix F).

Table 8: Volumes required to maintain levels at 79.1 m AHD (SWET modelling output)

Result	
Mean long-term (LT) annual controlled inflow requirement	1,157ML/year
95th percentile of mean LT annual controlled inflow requirement	3,245ML
Average LT controlled inflow requirement for filling periods	2,905ML
Record length	118
No. of periods	118
Years with no inflow	71 in 118
No. of draw downs over record	47
No. of draw downs not fully drawn down	15
% of draw downs not fully drawn down	32%
95th percentile duration of full period (months)	4.4
50th percentile duration of full period (months)	3.9

Following is a brief description of each the main results:

- **Mean long-term annual controlled inflow requirement**: the total amount of water to be put into the wetland annually in a controlled fashion to achieve the specified level and the desired regime (excluding natural inflows from rainfall and local catchment runoff). This is the average over the modelled period, which may include years with zero water required. A mean long term annual volume of 1,157 ML is required.
- **95th percentile of mean long-term annual controlled inflow requirement**: an estimate of the maximum volume ever likely to be required over any 12 month period (3,245 ML).
- **Average long-term controlled inflow requirement for filling period**: the total amount of water to be put into the wetland in a controlled fashion to achieve the desired water level regime for the recommended period. This excludes natural inflows from rainfall and local catchment runoff. Therefore, the total volume required would be approximately 2,905 ML.

Refer to Appendix F for greater detail.

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

5.4 Mitigation water

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

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

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

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

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

Step 1: Describe the desired water or flow regime

Step 2: Determine the baseline year incidental water contribution

Step 3: Assess dependency on baseline incidental water contributions

Step 4: Calculate the annualised baseline mitigation water volume

Step 5: Calculate the mitigation water commitment

Step 6: Calculate the LTCE mitigation water volume

5.4.1 Lake Murphy mitigation water

Step 1: Describe the desired water or flow regime

The desired filling frequency is the water regime required to achieve the ecological objectives and water management goal identified in Section 5.

The desired water regime for Lake Murphy is filling the wetland to approximately one metre deep two in five years and ensuring an inundation period of at least six months.

Step 2: Determine the baseline year incidental water contribution[3]

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

Leakage and seepage (from the channel) have not been accounted for within the following steps. Preliminary calculations to estimate the potential contributions to Lake Murphy from seepage from the no. 17/2 main supply channel were completed based on the localised impact assessment method outlined in the Water Change Management Framework (NVIRP 2010). The results indicate that a range of 7 ML/year to 27 ML/year may be received by Lake Murphy (Appendix G).

Significant leakage from the outfall structure to the wetland occurs during the irrigation season when the supply channel holds water. The leakage has not been quantified and is not recorded by G-MW. However, it has been accounted for in the mitigation water dependency assessment (following steps) as it supports a confined community in the wetland's inlet channel.

If future NVIRP actions are likely to impact the potential for leakage and seepage to reach Lake Murphy either via the channel system (i.e. lining the main supply channel or decommissioning other channels within 200 m of the wetland) or through the outfall structure (rationalisation or upgrade), an analysis will be triggered in accordance with the Water Change Management Framework.

The baseline year (2004-05) outfall volume recorded at the regulating structure was 0 ML, refer to Section 4.1.

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

Table 9: Determination of the baseline year incidental water contribution

Hydrological connection or incidental water source (e.g. Outfall #)	Baseline year incidental water at origin (Gross) (ML)	Estimated losses between the origin (irrigation system) and wetland (for baseline year) (ML)	Baseline year incidental water contribution at the wetland (Net) (ML)
Outfall #ST003951			
Recorded outfalls	0	0	0
Unrecorded leakage	unquantified	0	unquantified
Total			

[3] Incidental water contributed in the baseline year for each hydrological connection i.e. outfall water, seepage and leakage of a supply channel within 200m of the wetland and leakage from supply infrastructure.

Step 3: Assess dependency on baseline incidental water contributions

The Water Change Management Framework specifies criteria to be applied in assessing whether mitigation water is required for a wetland or waterway with high environmental values (NVIRP 2010). These criteria have been assessed for Lake Murphy with the results presented in Table 10.

Table 10: Mitigation water dependency assessment

Criteria by which mitigation water may be assessed as not required	Link between incidental water (losses) and environmental values
1. Mitigation water may be assessed as not required where:	
1.1 There is no hydraulic connection (direct or indirect) between the irrigation system and the wetland or waterway	A short delivery channel delivers water to Lake Murphy from the drop board structure.
1.2 The water does not reach the wetland or waterway with environmental values (e.g. the outfall is distant from the site and water is lost through seepage and evaporation before reaching the area with environmental values)	No outfall water is recorded. Leakage from the structure maintains the delivery channel between the regulator and the wetland proper.
2. Mitigation water may be assessed as not required where the wetland or waterway receives water from the irrigation system:	
2.1 That is surplus to the water required to support the environmental values (e.g. changing from a permanently wet to an intermittently wet or ephemeral regime is beneficial or has no impact)	The wetland does not have more water than is required to support the desired state of the environmental values. It is currently dry.
2.2 That occurs at a time that is detrimental to the environmental values	Lake Murphy is recommended to be managed as a deep freshwater marsh. Pulse flows are required annually to maintain the confined community within the inlet channel by providing a pulsed flow regime over the October/April period.
2.3 That is of poor quality (or results in water of poor quality entering a site e.g. seepage resulting in saline groundwater intrusions to wetlands) and the removal of which would lead to an improvement in the environmental values	Losses (irrigation outfalls) are of acceptable water quality.
3. Mitigation water may be assessed as not required where the environmental values:	
3.1 Do not directly benefit from the contribution from the irrigation system (e.g. River Red Gums around a lake may not directly benefit from an outfall and may be more dependent on rainfall or flooding)	Losses (leakage) would maintain the confined community within the inlet channel. Maintaining this community would enhance opportunities for recolonisation of Lake Murphy when filled.
4. Mitigation water may be assessed as not required where the removal of the contribution from the irrigation system does not:	
4.1 Increase the risk of reducing the environmental values (e.g. outfalls form a very small proportion of the water required to support the environmental values and their removal will not increase the level of risk)	Losses would contribute to maintaining the confined community within the inlet channel and would enhance opportunities for recolonisation of Lake Murphy when filled.
4.2 Diminish the benefits of deploying any environmental water allocations (over and above the contribution from the irrigation system).	If outfall volumes were reduced, additional water would need to be secured for: • Providing annual flows to maintain the confined community within the inlet channel.

The assessment of the requirements for mitigation water for Lake Murphy demonstrates that outfalls provide no benefit to the wetland and therefore mitigation water for this baseline incidental water contribution is not required. However, **the leakage from the outfall structure provides benefits to the wetland and provision of mitigation water is warranted (if rationalisation of infrastructure or upgrading of the outfall structure occurs)**. If the leakage of water was reduced or removed, additional water would need to be secured to provide annual flows to maintain the vegetation, which provides habitat for a variety of fauna species and enhances opportunities for recolonisation of Lake Murphy when filled.

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

The outfall volume is zero and the leakage through the drop board structure has not been quantified as it will not be impacted unless rationalisation or upgrade of the outfall structure occurs. As noted in Step 2, if NVIRP actions are likely to impact on the leakage from the outfall structure, then quantification of the leakage and calculation of the mitigation water commitment will be required i.e. Step 4 (calculation of annualised baseline mitigation water volume), Step 5 (calculation of the mitigation water commitment) and Step 6 (calculation of the Long-term Cap Equivalent Volume) will need to be completed.

5.5 Other water sources

Mitigation water is recommended for Lake Murphy if the existing drop board structure is rationalised or upgraded at which time the leakage will need to be quantified. NVIRP are only accountable for mitigating any potential impact from the project i.e. for provision of mitigation water as a proportion of the total outfall, seepage and leakage volumes received by the wetland if they are supporting significant environmental values. As such, it is important that the environmental water holder secures additional sources of water to maintain Lake Murphy as a deep freshwater marsh supporting a range of environmental values. The most likely additional sources of environmental water will be existing and future environmental entitlements.

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

5.5.1 Murray flora and fauna bulk entitlement

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

5.5.2 75 GL environmental entitlement

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

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

5.5.3 Commonwealth environmental water

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

The *Water Act 2007* provides that “the Commonwealth Environmental Water Holder must perform its functions for the purpose of protecting or restoring environmental assets so as to give effect to relevant international agreements”. Wetlands of International Importance (Ramsar) are considered priority environmental assets for use of the commonwealth environmental water (DEWHA 2008). Whilst Lake Murphy is not a wetland of international importance, it is a refuge for species listed under other international conventions. Therefore, a case for the receipt of Commonwealth environmental water could be made.

6. Potential risks or adverse impacts

An important component of the EWPs is the identification of potential risks, limiting factors and adverse impacts associated with the delivery of the desired water regime of which mitigation water, if recommended, represents only a portion. Awareness of the potential risks and impacts will influence future intervention and long-term condition monitoring undertaken at Lake Murphy, will inform the adaptive management of the water regime and the provision of mitigation water (Section 8).

Table 11 outlines the risks, limiting factors and potential impacts associated with the provision of mitigation water as a component of the desired water regime that need to be considered by NVIRP in conjunction with the environmental water manager.

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

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

Table 11: Potential risks, impacts and mitigation measures associated with the desired water regime for Lake Murphy

Risks/limiting factors	Impacts	Mitigation measures
Limited water availability (i.e. no environmental water allocation to provide desired water regime)	Loss of high environmental values. Failure to achieve identified objectives and water management goal.	Ensure regulator continues to leak. Undertake mitigation water assessment if rationalisation or upgrade to the outfall structure is planned. Ensure sufficient information is collected for prioritisation of Lake Murphy in environmental allocation processes. Review rainfall and climate data to utilise natural inflows where possible.
Ineffective delivery	Inability to deliver water in order to achieve objectives and water management goal.	Ensure that the delivery capacity is sufficient to facilitate delivery of required volumes at critical times (e.g. delivery share)

7. Water delivery arrangements

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 outfall structure (drop-bar) that supplies Lake Murphy is located at the northern side of Lake Murphy East (Figure 8) and has a reported capacity of 70 ML/day. The 17/2 channel has a capacity of approximately 180 ML/day. The channel capacity from the outfall to the wetland is currently restricted by willows (Figure 8) though the reduction in capacity is unquantified. There is currently no outlet to flush the wetland.

At a flow rate of 70 ML/day it will take a minimum of 30 days to fill Lake Murphy 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. This duration for filling is considered to be sufficient to meet the required watering regime for the wetland.

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.

As previously noted, there is significant leakage from the drop-bar outfall structure. The volume of this water is not quantified; however it is providing an environmental benefit by maintaining an area of aquatic macrophytes in the outfall channel. This assemblage appears to filter the water entering and acts as a source of biological activity for the rest of the wetland.

It is recommended that the outfall structure to Lake Murphy is not upgraded so that this leakage is maintained. If any upgrades are scheduled either to the outfall structure or the 17/2 channel, the volume of leakage should be quantified and assessed through the mitigation water calculation process.

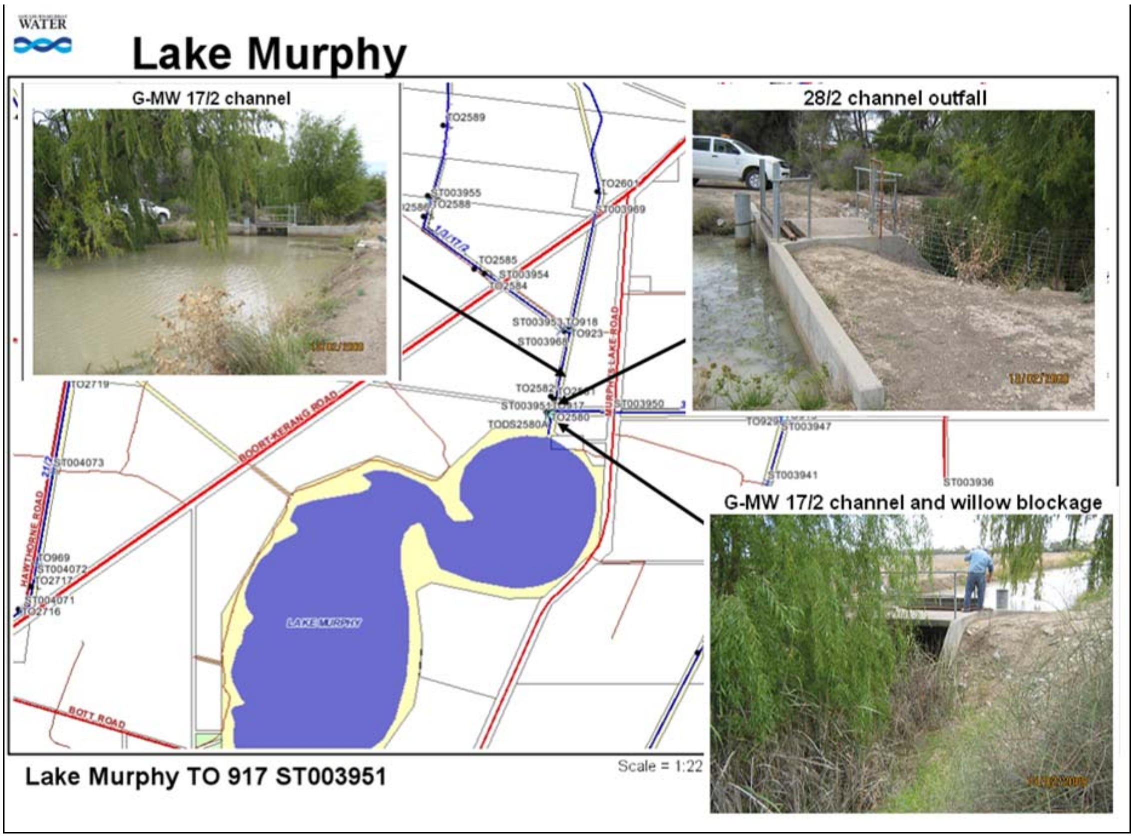

Figure 8: Lake Murphy infrastructure

7.1 NVIRP works program – channel 17/2

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 backbone channel within the vicinity of Lake Murphy is the Torrumbarry 17/2 Channel which will be automated down to the 3/17/2 channel offtake, approximately 1.4 km upstream of the Lake Murphy outfall structure.

NVIRP are responsible for "retain(ing) infrastructure and improving where practicable, where it will be required for delivering environmental water…." (NVIRP 2010). A review of the infrastructure requirements and supply arrangements will need to be undertaken if channel 3/17/2 is considered for rationalisation. Quantification of the leakage from the outfall structure as part of the mitigation water assessment process will also be required.

7.2 Infrastructure recommendations

As noted above, the infrastructure servicing Lake Murphy needs to be retained or an alternative supply investigated (if rationalisation is proposed) to ensure environmental water delivery is possible.

Potential upgrade options that should be considered to improve operational management of Lake Murphy include:

- Removal of the Willow blockage in the outfall channel that is restricting capacity. Estimated cost for works - $10,000 (Rob O'Brien, DPI, pers. comm. 2009)
- Installation of a Common Carp screen
- The replacement of the existing drop-bar outfall structure to a fully automated structure.

Removal of the willows blocking the outfall channel would significantly enhance the efficiency and effectiveness of water delivery to Lake Murphy.

Replacement and upgrade of the existing outfall structure to Lake Murphy would improve operational management by minimising losses (bar leakage), and enhancing safety and useability. It is estimated that upgrading this structure would cost approximately $40,000 (Paul Lacy, NVIRP and Rob Chant, G-MW, pers. comm. 2009). As noted above however, if an upgrade is planned, quantification of the leakage should occur to ensure no negative impacts on the wetland.

In addition, Common Carp are abundant within the G-MW channel system and there is currently no carp screen between the channel system and Lake Murphy. 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. In particular, there is potential for enormous benefit in installing a carp screen to prevent larger fish entering the wetland when filling from empty following a dry period (pers. comm. Rob O'Brien [DPI] 30 March 2010).

It is recommended that a carp screen is installed to prevent larger 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.
- 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 readily accessible.
- Regular maintenance will be required during regulator operation to prevent blockages.
- Installation will reduce the hydraulic capacity of the regulator (SKM 2005).

The works and potential upgrade options recommended above are outside the scope of NVIRP, unless rationalisation of channels impacts on the current delivery system to the wetland.

8. Adaptive management framework

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

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

Table 12: Adaptive management framework

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

8.1 Monitoring and reporting

Mitigation water is not currently recommended for Lake Murphy, therefore there is no requirement for NVIRP to report, annually, on the contribution, or provision, of 'NVIRP Mitigation Water' towards achieving the water regime as with other EWPs. However, if the outfall regulating structure is upgraded or rationalised, the leakage will be quantified and the mitigation water assessment reviewed.

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

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

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

8.2 Review

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

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

8.3 Adjustment

Adjustments may be made to:

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

These adjustments will be incorporated into the EWP.

9. Governance arrangements

A summary of the roles and responsibilities of the various bodies relating to the delivery and review of management and mitigation measures is provided in Table 13 (NVIRP 2010). The table outlines the roles and responsibilities before and during the implementation of NVIRP in the modified GMID.

Table 13: Roles and responsibilities

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

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

<table>
<tr><th>Agency</th><th>Assess and develop management and mitigation measures</th><th>Deliver and review management and mitigation measures during NVIRP implementation</th></tr>
<tr><td></td><td></td><td>Report annually on the availability and delivery of water for mitigating environmental impacts as part of reporting upon meeting obligations under its bulk entitlement. In some instances, it will be appropriate to measure mitigation flows to ensure mitigation volumes of water are delivered.
Work closely with NVIRP</td></tr>
<tr><td>DSE</td><td>Identify and inform NVIRP of opportunities for best practice.
Participate in Technical Advisory Committee.
Arrange funding to enable environmental water manager, catchment manager and land manager to deliver agreed measures.
Develop policies to address relevant issues (assuming that other agencies will participate in policy development).</td><td>Participate in the periodic review of the Water Change Management Framework and relevant EWPs.
Conduct review as part of the long-term water resource management; a requirement specified in Section 22L of the Water Act 1989. The process will allow:
- the balance of the environmental obligations and consumptive water to be assessed and restored based on certain conditions.
- the need for the obligation reviewed based on the environmental values at the time of the review.</td></tr>
<tr><td>Environmental Water Holder (to be established)
DSE pending appointment of the Environmental Water Holder</td><td>Environmental Water Holder not yet in place. Role fulfilled by DSE in the meantime.</td><td>Hold and manage environmental entitlements, including mitigation water that becomes a defined entitlement.
Consult with CMAs in identifying priority wetlands, waterways and groundwater systems for environmental watering. Plan and report on the use of environmental entitlements.
Participate in the periodic review of relevant EWPs.
Negotiate with Commonwealth Environmental Water Holder to arrange delivery of Commonwealth environmental water.</td></tr>
</table>

9.1 Framework for operational management

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

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

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

Mitigation water will be able to be carried over in line with other entitlements and will only be supplied to those wetlands where a mitigation water requirement has been identified. The specification of the volume and use of mitigation water will be the same regardless of whether it is established via bulk entitlement or contract.

There is no mitigation water recommended for Lake Murphy, however the if the existing drop board structure is rationalised or upgraded at which time the leakage will need to be quantified and mitigation water provided.

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

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

The main components are:

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

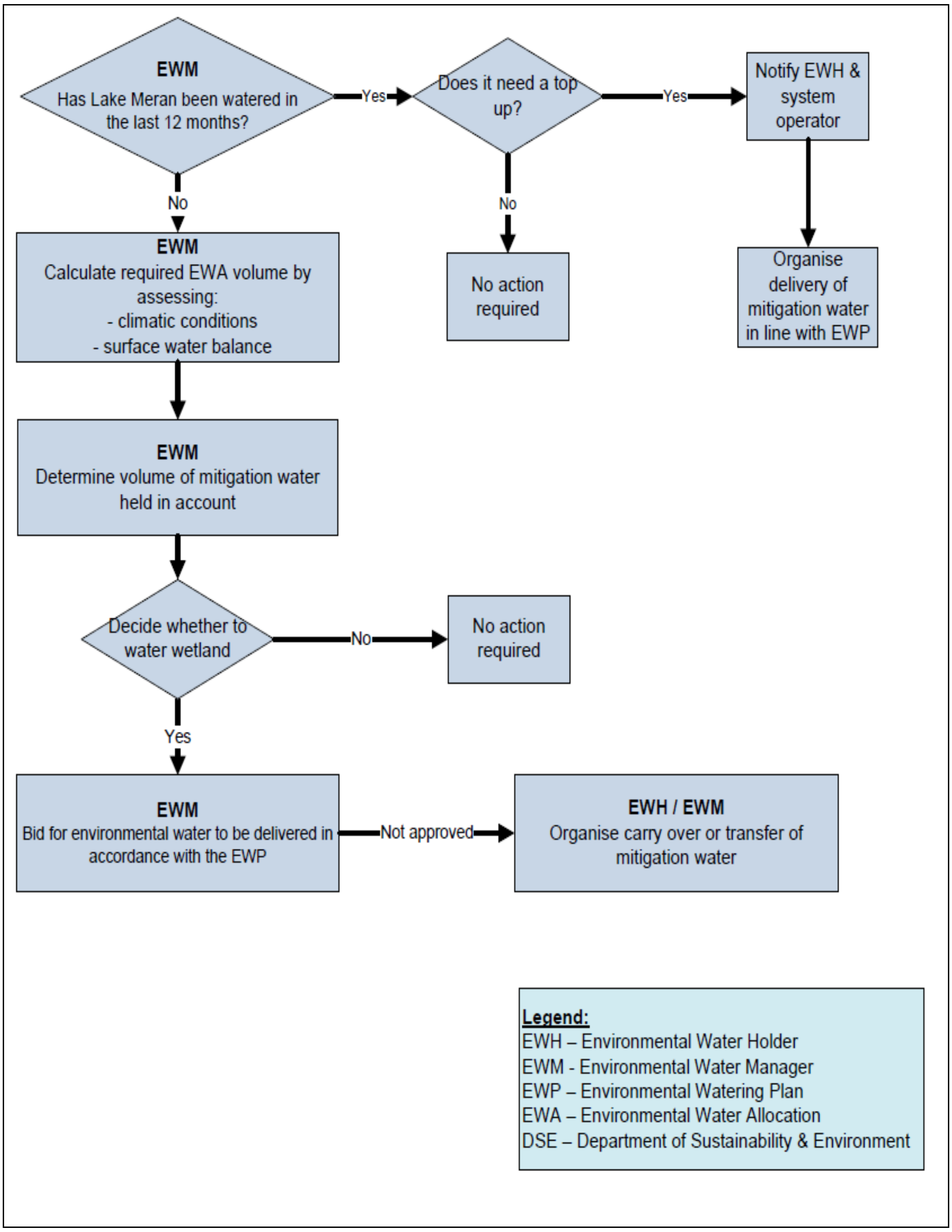

Figure 9: Operational management framework

10. Knowledge gaps

The Lake Murphy 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 Works program

Further information on the NVIRP works program in the vicinity of Lake Murphy needs to be confirmed to more specifically assess the potential impacts on the wetland, assessing:

- The potential rationalisation of 3/17/2 channel, on which the Lake Murphy outfall structure is located.

10.2 Lake Murphy

- The current dry climate conditions are impacting on groundwater levels around the lake.
- Salinity levels in the wetland bed (through an accumulation of salt) may impact on the ability for plants to recolonise in the future particularly in Lake Murphy West.
- Continued monitoring and evaluation of groundwater and surface water data is recommended as well as lake bed levelling to verify the current lake level.
- 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.
- The volume of water leaking from the outfall structure is unknown and quantification should be undertaken prior to any change to the operation of the system in the vicinity of the wetland.
- The relationships between hydrology and ecology 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.

10.3 Roles and responsibilities

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

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

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 for 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 that will add value to the development of the plan have been noted.

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 and agency participants

- John Murphy (Landholder)
- Barry Baulch (Landholder)
- Alan Marshal (Landholder)
- Robin Algae. (GMW Bailiff)
- Chris Coleborn (Birds Australia Member)

Comments and feedback from participants for Lake Murphy

- Lake Murphy was naturally flooded in a Loddon River flood event.
- Floodwater entered the lake via a main creek line that carried water from the river, through Fowler/Daves Swamp then into Lake Murphy.
- Lake Murphy became completely cut off from floodwater after the Torrumbarry Irrigation System was developed (i.e. 17/2 Channel Construction).
- The creek lines connecting Lake Murphy to the Loddon River had Red Gums along them; however, Lake Murphy only supported Black Box trees.
- There were numerous large Black Box trees in Lake Murphy but they were probably drowned (pre-1900).
- The bigger, old dead Black Box trees were cut up for fire wood over time.
- Lots of water was historically outfalled from the G-MW channel into Lake Murphy, maintaining it mostly full.
- Water was historically escaped into the wetland, particularly when surrounding landholders finished watering during the middle of the night. They would lift a board from the G-MW outfall structure into Lake Murphy allowing water to flow into the lake.
- Water bailiffs would intentionally outfall water into the lake to attract ducks for duck opening.
- One year, Premier Henry Bolty expressed interest in shooting ducks in the Kerang Lakes area and the Department organised for Lake Murphy to be filled to ensure a successful duck opening
- More recently, landholders and G-MW bailiffs avoid outfalling any water into Lake Murphy by travelling up to the off-take channel (17/2) and closing down the water source, eliminating the need to inject water into the lake.
- Virtually no water has been outfalled or escaped into the wetland in the last five years.

- There are several farms that drain back into Lake Murphy; however, due to recent water trading out of the area, the local catchment is much drier and therefore it's expected that there will be a large reduction in local catchment water draining into Lake Murphy in the future.
- Conservation Forests and Land would also deliver environmental water into Lake Murphy.
- Landholders around Lake Murphy were asked to sign an agreement or approval prior to the Department delivering water to the wetland.
- The correct name for this wetland is 'Murphy's Lake' not 'Lake Murphy' and should be changed back.
- There have always been good waterbird numbers present at Lake Murphy. Historically there may have been a few more, particularly through wetter periods.
- Thousands of ducks were present on the lake when the lake was maintained higher by channel outfall from the mid 1950s onwards, until the lake levels were dramatically reduced.
- Swans and some ducks (Blue Bills) would nest and breed there when there was plenty of water in the lake.
- Ducks were shot in very high numbers in Lake Murphy, dozens at a time – but they were also caught in duck traps and enticed in by feeding out grain.
- Ribbon Weed was common when Lake Murphy's water levels were kept high and Red Fin were regularly caught in gill nets by locals.
- When cumbungi spread across much of Lake Murphy East, the number of waterbirds decreased.
- Frogs are present is very high numbers and are currently living in the cumbungi, particularly when water or large rainfall events stimulates them; calls are very loud at night.
- The cumbungi spread because the water levels in the lake reduced (fewer outfalls). Shallow warm water, over summer, suits this plant and it took over and became a weed.
- Some of the past fires at Lake Murphy were intentionally lit, most likely to reduce the thick cumbungi beds.
- Some people would currently like to burn Lake Murphy East.
- Athol Pine escaped from a mature tree situated at the original Murphy family house block.
- The willow trees on the north end of Lake Murphy East were planted by duck hunters several years ago.
- The east side of the wetland was always wetter as it received the water directly from the G-MW outfall channel.
- The constant channel outfall possibly protected Lake Murphy East from going saline
- The larger western side dried out more frequently than the smaller eastern side.
- Saline land and its associated drainage, south of Lake Murphy, was partially responsible for the main swamp (Lake Murphy West) going saline.
- Lake Murphy has dried out more frequently over the past 10–12 years due to less outfall and drainage water.
- The current water regime is a waste of water and dries up too quickly; the wetland would be better left dry or only filled during very years.
- Often the swans nest but their young are eaten by foxes as the water dries up and exposes them.

- Filling Lake Murphy probably causes an increase in groundwater levels in the local area.
- The wetland is highly productive as part of the current wet/dry water regime and supports a high and diverse number of waterbirds.
- There needs to be continued delivery of environmental water to this wetland; however, it might be best to do this during wetter seasons and where there are higher water allocations.

Appendix C: Wetland characteristics

CHARACTERISTICS	DESCRIPTION
Wetland Name	Lake Murphy
Wetland ID	7626 587335
Wetland Area	168 ha
Conservation Status	Bioregional Important Wetland
Land Status	State Wildlife Reserve, Utilities and Survey
Land Manager	Parks Victoria, Goulburn Murray Water
Surrounding Land Use	Broadacre dryland cropping
Water Supply	Natural: Wandella Creek and Loddon River Current: Channel outfall (3/17/2) • 300EC • Capacity of 70 ML/day (approx 30 days to FSL)
1788 Wetland Category	Shallow Freshwater Marsh
1994 Wetland Category	Deep Freshwater Marsh
Wetland Capacity	2000 ML, *FSL 78.0 m AHD* *(Not including wetting up losses, e.g. seepage)* Depth of Wetland (Range): 1-1.5 metres
Outfall Volumes	0 ML (04/05) 0 ML (98/99 to 06/07 average) *Please note: small outfall observed during field assessments*

Appendix D: Flora and fauna species list

Compiled: March 2009

Sources:

DSE (2009a)

Ecos Environmental Consulting (2006)

Saddlier *et al.* (2009)

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

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

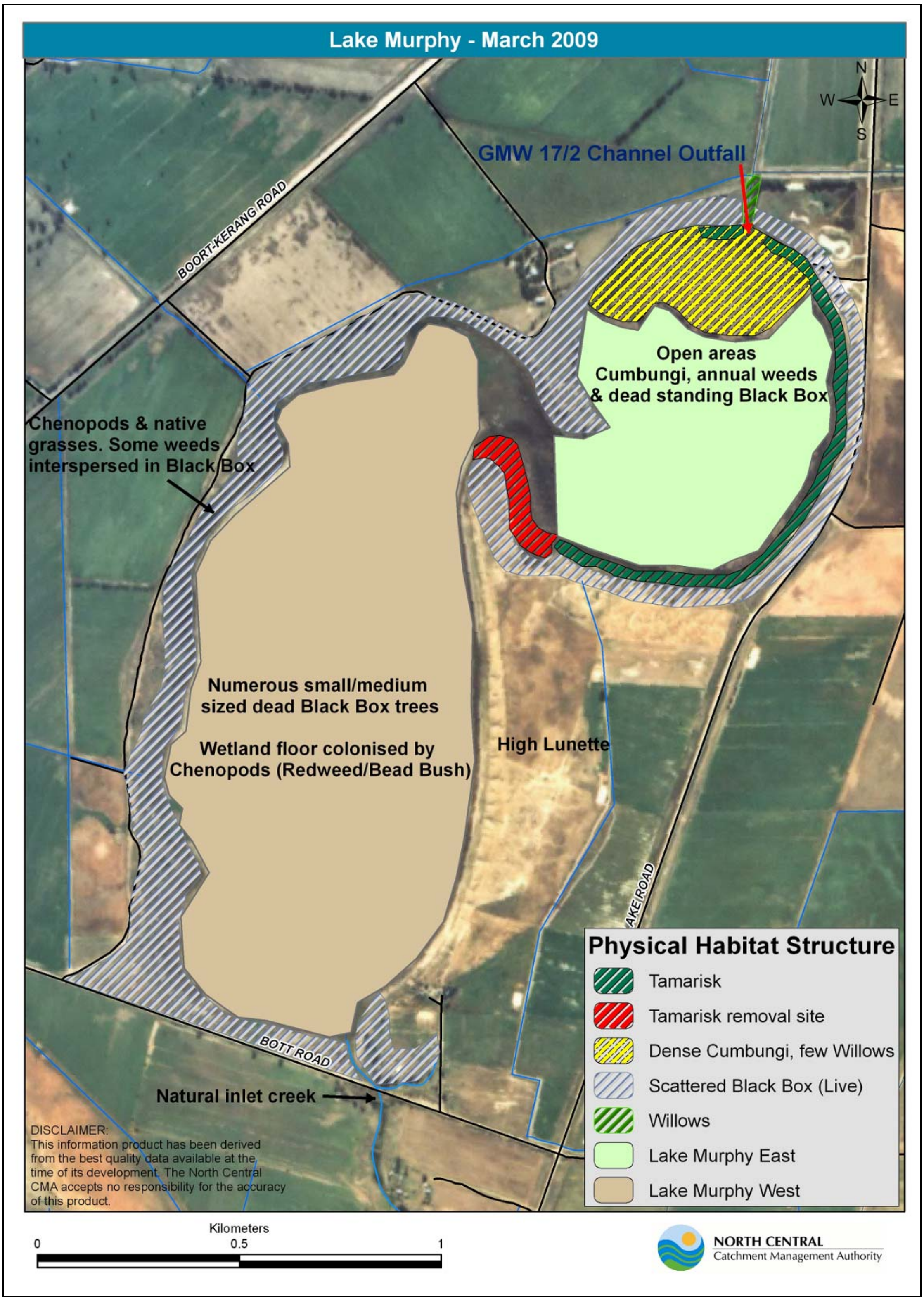
Data Source: 'Aquatic Fauna Database', Copyright - The State of Victoria, Department of Sustainability and Environment.

Common name	Scientific name	Dates recorded
Native		
Australasian Shoveler	*Anas rhynchotis*	1987, 1988, 1989, 1990, 1991, 1992, 1993, 1994, 1995, 1996, 1997, 1998, 2000
Australian Pelican	*Pelecanus conspicillatus*	1992
Australian Shelduck	*Tadorna tadornoides*	1987, 1995
Australian Wood Duck	*Chenonetta jubata*	1989
Bar-tailed Godwit	*Limosa lapponica*	Likely to occur (ARI 2009)
Berry (creeping) Saltbush	*Atriplex semibaccata*	1990, 2004
Black Box	*Eucalyptus largiflorens*	1990, 2004
Black Swan	*Cygnus atratus*	Likely to occur (ARI 2009)
Black-tailed Native-hen	*Gallinula ventralis*	1989, 1990, 1991, 1994, 1996, 2002
Blue-billed Duck	*Oxyura australis*	1990, 1993, 1996, 1998
Brolga	*Grus rubicunda*	1985, 1988, 1997
Cane Grass	*Eragrostis australasica*	1990
Caspian Tern	*Sterna caspia*	1991
Chariot Wheels	*Maireana cheelii*	1990
Climbing Saltbush	*Einadia nutans*	1990
Coarse Green Algae	*Enteromorpha spp.*	1990
Common Greenshank	*Tringa nebularia*	Likely to occur (ARI 2009)
Common Nardoo	*Marsilea drummondii*	1990
Cumbungi	*Typha spp.*	1990
Curlew Sandpiper	*Calidris ferrginea*	Likely to occur (ARI 2009)
Dense Stonecrop	*Crassula colorata*	1990
Dillon Bush	*Nitraria bittardieri*	1990
Duckweed	*Lemna minor*	1990
Dusky Moorhen	*Gallinula tenebrosa*	1989, 2000, 2003
Eastern Great Egret	*Ardea modesta*	Likely to occur (ARI 2009)
Eurasian Coot	*Fulica atra*	1987, 1988, 1989, 1990, 1991, 1992, 1993, 1998, 2006
Ferny Azolla	*Azolla pinnata*	1990
Fine Green Algae	*Enteromorpha spp.*	1990
Five Spined Roly Poly	*Sclerolaena muricata*	1990, 2004
Freckled Duck	*Stictonetta naevosa*	1981, 1987, 1988, 1989, 1990, 1991, 1992, 1999
Fuzzweed	*Vittadinia sp.*	1990
Glasswort	*Halosarcia pergranulata ssp.*	1990

Common name	Scientific name	Dates recorded
Glossy Ibis	*Plegadis falcinellus*	1985, 1988, 1989,
Great Cormorant	*Phalacrocorax carbo*	1992
Great Egret	*Ardea alba*	1988, 1989, 1994, 1997, 2000
Halosarcia	*Halosarcia spp.*	2004
Hardhead	*Aythya australis*	1987, 1988, 1989, 1990, 1991, 1993, 1994, 1998,
Hoary-headed Grebe	*Poliocephalus poliocephalus*	2006
Hyssop Loosestrife	*Lythrum hyssopifolia*	1990
Jointed Rush	*Juncus articulatus*	1990
Little Black Cormorant	*Phalacrocorax sulcirostris*	1995
Little Egret	*Egretta garzetta*	1988, 1994
Little Pied Cormorant	*Microcarbo melanoleucos*	1988
Marbled Gecko	*Christinus marmoratus*	1989
Marsh Sandpiper	*Tringa stagnatilis*	Likely to occur (ARI 2009)
Musk Duck	*Biziura lobata*	1988, 1989, 1990, 1991, 1993, 1994, 1996, 1998
Nitre Goosefoot	*Chenopodium nitrariaceum*	1990
Pacific Azolla	*Azolla filiculoides*	1990
Pacific Black Duck	*Anas superciliosa*	1977
Peppercress	*Lepidium africanum*	1990
Pied Cormorant	*Phalacrocorax varius*	2000
Plains Froglet	*Crinia parinsignifera*	1995
Purple Swamphen	*Porphyrio porphyrio*	1988, 1989, 1990, 1991, 1992, 1994, 1997, 2000
Red Gum	*Eucalyptus camaldulensis*	1990
Red-necked Stint	*Calidris ruficollis*	Likely to occur (ARI 2009)
Royal Spoonbill	*Platalea regia*	1988, 1989, 1990, 1994, 1997, 2000
Ruby Saltbush	*Enchylaena tomentosa*	1990, 2004
Sago Pondweed	*Potamogeton pectinatus*	1990
Sea Tassel	*Ruppia spp.*	1990
Sharp-tailed Sandpiper	*Calidris acuminata*	Likely to occur (ARI 2009)
Short-winged Copperburr	*Scleroclamys brachyptera*	1990
Slender Fruited Saltbush	*Atriplex leptocarpa*	1990, 2004
Slender Knotweed	*Polygonum minus*	1990
Small River Buttercup	*Rununculus rivuleris*	1990
Spiny Lignum	*Muehlenbeckia horrida*	1990
Spiny Sedge	*Cyperus gymnocaulus*	1990
Tangled Lignum	*Muehlenbeckia florulenta*	1990
Tiny Duckweed	*Wolffia australiana*	1990
Variable Spear Grass	*Stipa variabilis*	1990
Wallaby Grass	*Danthonia caespitosa*	1990
Water Couch	*Paspalum distichum*	1990
Whiskered Tern	*Chlidonias hybridus*	1988, 1989, 1991
White-bellied Sea-Eagle	*Haliaeetus leucogaster*	Likely to occur (ARI 2009)
White-fronted Chat	*Epthianura albifrons*	2001
Wood Sandpiper	*Tringa glareola*	Likely to occur (ARI 2009)
Woolly buttons	*Leiocarpa panaetioides*	1990
Yanga Bush	*Maireana brevifolia*	1990
Exotic		
African Boxthorn	**Lycium ferocissimum*	1990
Barley Grass	**Critesion murinum*	1990

Common name	Scientific name	Dates recorded
Buckhorns Plantain	**Plantago coronopus*	1990
Burr Medic	**Medicago polymorpha*	1990
Capeweed	**Arctotheca calendula*	1990
Common Carp	**Cyprinus carpio*	1990
Common Sow Thistle	**Sonchus oleraceus*	1990
Couch Grass	**Cynodon dactylon*	1990
Curled Dock	**Rumex crispus*	1990
Cut-Leaf Medic	**Medicago laciniata*	1990
Ferny Cotula	**Cotula bipinnate*	1990
Horehound	**Marrubium vulgare*	1990
Madrid Brome	**Bromus madritensis*	1990
Medic	**Medicago spp.*	2004
Mosquitofish	**Gambusia holbrooki*	1990
Paradoxical Canary Grass	**Phalaris peradoxa*	1990
Prickly saltbush	**Salsola kali*	2004
Rats Tail Fescue	**Vulpia myuros*	1990
Rye Grass	** Lolium spp.*	1990
Scorzonera	**Scorzonera laciniata*	1990
Sea Barley Grass	**Critesion marinum*	1990, 2004
Slender Barb Grass	**Parapholis strigose*	1990
Small ice plant	**Mesembryanthemum nodiflorum*	2004
Spear Thistle	**Cirsium vulgare*	1990
Spiny Rush	**Juncus acutus*	1990
Tamarisk	**Tamerix aphylla*	1990
Water Buttons	**Cotula coronopifolia*	1990
Wild oats	**Avena fatua*	2004
Wimmera rye-grass	**Lolium rigidum*	2006
Woolly Clover	**Trifolium tomentosum*	1990

Appendix E: Vegetation composition map - March 2009



Appendix F: Hydrology (SWET OUTPUT)

set	Wetland Name	Lake Murphy							
		Degrees	Degrees	Minutes					
set	Latitude	-35.80681	-35.00	48.4083					
set	Longitude	143.86437	143.00	51.8623					
		Metres (AHD)							
	Altitude	79.1						Runoff coefficient	
		ha	m^2	ML/ha/y	ML/yr	Rainfall	Total (ML)	Mean	Max.
set	Local contributing catchment area	1600	16000000	0.2	320	348	5560	0.058	0.2
		%area	Depth						
set	Initial loss to wetland bed parameters	0.25	300						
		Mean	Max						
set	Assumed average wetland bed runoff coeff	0.150	0.40						
		ML/d							
adjust	Notional artificial wetland filling inflow rate	70							
		mm/day							
adjust	Maximum artificial filling rate	20							

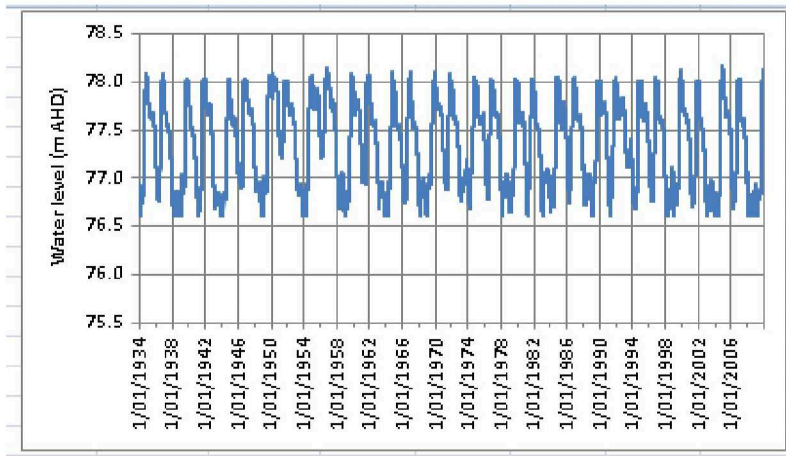
To operate the model
First fill in the required input data cells. Calculation is set to Manual, so when ready press Function9 (F9) key
It takes 20 seconds to re-calculate and plot

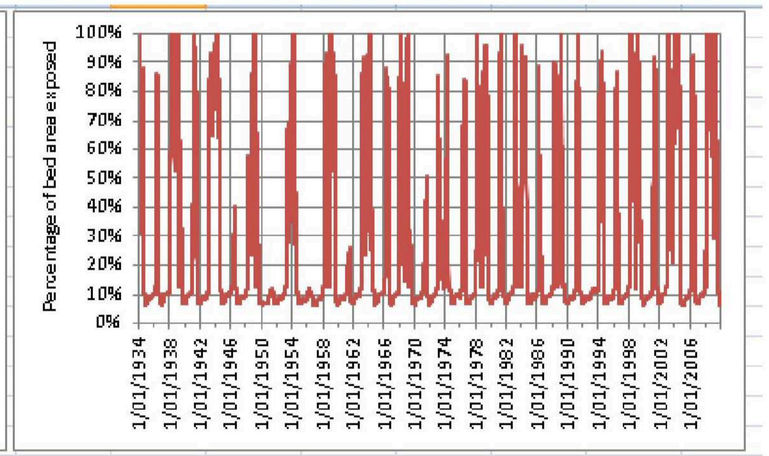
		Day	Month	
adjust	Irrigation year start	1	8	
		Elevation	Volume	Area
set	Wetland spill level	79.1	3950000	2E+06
		Elevation	Tolerance for drying (m)	
adjust	Lowest wetland level	76.6	0.1	
			1 = Pan; 2 = Modelled	
choose	Factored Pan evaporation or modelled ET method?		2	

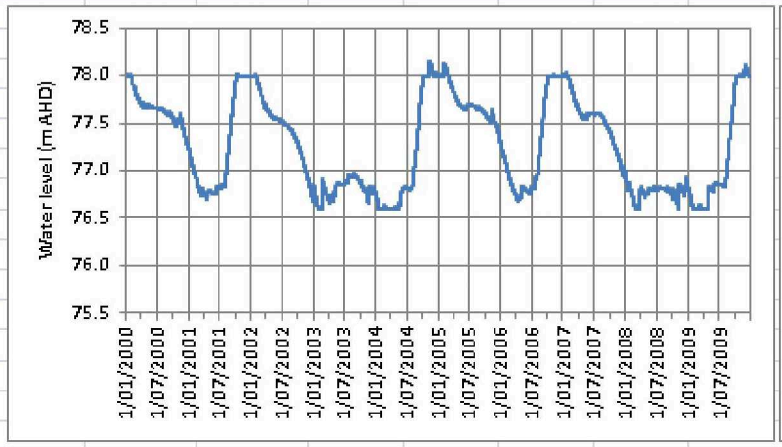
RESULT			
Calculated for irrigation year	Mean (ML/yr)	P95 (ML/yr)	Years with no inflow
Mean long-term annual artificial water inflows	1,157	3,245	71 in 118 years
	ML	No. Periods	Record length (years)
Average artificial water inflows for filling periods	2,905	47	118
Drawdowns over record (number of)	47		
Drawdowns not fully dried out (number of)	15		
Drawdowns not fully dried out (percentage)	32%		
95th percentile duration of full period (months)	4.4		
50th percentile duration of full period (months)	3.9		

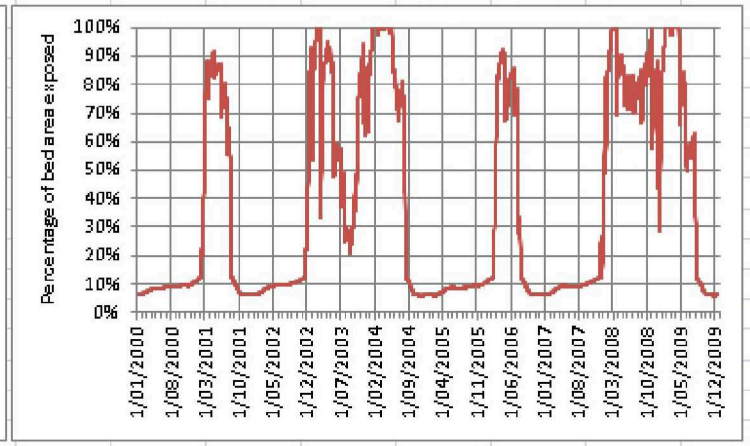
Fill cycle length (yr)	No. cycles
1	
2	24
3	23
4	
5	
6	
7	
8	
9	
10	

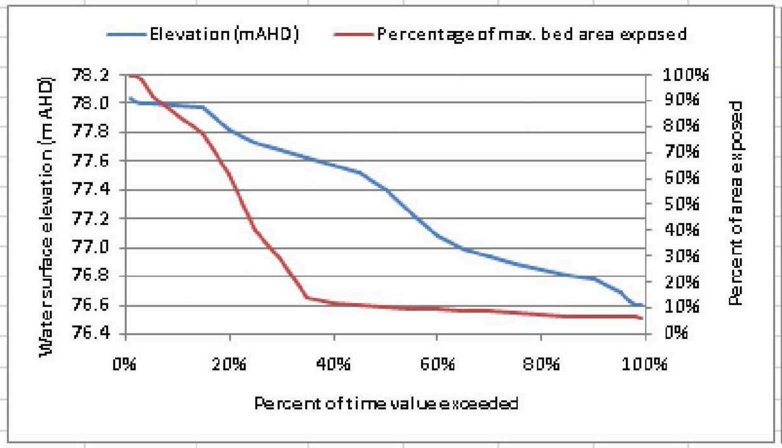
		Filling frequency									
set	Number (N) of filling events	2	events in								
set	Over management cycle length X (years)	5	years								
		If filling year		Filling		Staged drawdowns			Drawdown		
	Year	Duration (mt	Elevation (m)	Volume	Area	Y/N	Elevation (I	Durati	Volume	Area	
adjust	1	6	78	2E+06	1710000	N					
adjust	2										
adjust	3										
adjust	4	6	78	2E+06	1710000	N					
adjust	5										
adjust											
adjust											

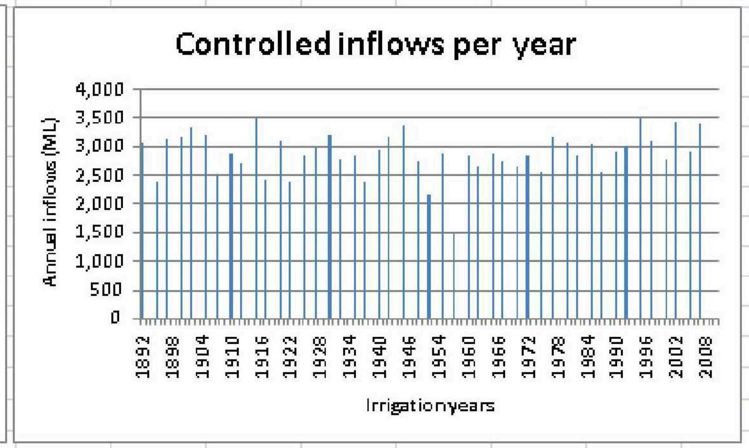












Appendix G: Preliminary leakage and seepage loss contribution calculations

Wetland	Wetland <200 m of main supply channel (Yes/no)	Length of channel (m) <200 m	Channel width (m)	Irrigation channel	Seepage Calculation Figures					Seepage Range (min - max)	
					Channel width category	5 mm/day (ML/yr)	10 mm/day (ML/yr)	15 mm/day (ML/yr)	20 mm/day (ML/yr)	ML/yr (@ 5 mm/day)	ML/yr (@20 mm/day)
Lake Murphy	Yes	100	10	channel 17/2	use 10 m	7	14	20	27	0.7	2.7

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

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

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

Appendix H: Additional risks and limiting factors

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

Risks/limiting factors	Impacts	Mitigation measures
Delivery of water		
Climatic variability	Variability in water availability (e.g. dry season in a planned wetting phase)	Adaptive management of watering regime and delivery options as above.
Poor water quality (i.e. high salinity, turbidity and nutrient levels)	Unsuitable habitat for waterbirds and food sources	Monitoring of groundwater levels, salinity and nutrient inputs to wetland and adaptive management of watering regime.
	Filamentous algal growth	
Groundwater intrusion due to elevated groundwater levels	Poor vegetation health	Monitoring of groundwater levels and salinity within wetland. Adaptive management of watering regime.
	Limited regeneration and dominance of salt tolerant species	
	Unsuitable habitat for waterbirds and food sources	
Lack of connection between wetland and a river or floodplain	Altered flow regime (continued lack of flood flows)	Investigate opportunities to reconnect Lake Murphy to the river and floodplain.
	Lack of connectivity throughout the landscape	
Flooding of adjacent landholders	Community angst	Monitor rainfall and climate data and adapt water delivery to account for potential flood events.
	Liability	
Ecological response		
Lack of seedbank viability	Restricted regeneration particularly of Black Box	Monitoring and adaptive management. Consider revegetation if necessary. Potential to test seed germination (samples taken from wetland bed).
	Emergence of unexpected native or exotic species	
No reliable supply of food/nesting sites	Limited occurrences of waterbirds	Seasonal water delivery, monitoring and adaptive management of watering regime.
Lag time between wetland watering and bird breeding	No successful breeding events	Seasonal water delivery, monitoring and adaptive management of watering regime.
Proliferation of pest plant and animal species e.g. Tamarisk and Spiny Rush	Establishment of native species limited by dominance of exotic species such as Tamarisk and Spiny Rush	Monitoring, active management (e.g. weed and pest control). Install European Carp screens.
	Limited habitat availability due to dominance of exotic species e.g. spiny rush	
	Predation	
High soil salinity	Poor establishment of native vegetation as salinity levels may be beyond threshold levels	Monitoring and adaptive management of watering regime, Active management (e.g. weed and pest control).
	Poor vegetation health	
Potential for further encroachment of native flora species	Undesirable expansion of monoculture of Cumbungi and Common Reed	Monitoring and adaptive management of recommended watering regime. Active management (e.g. spraying, slashing or crash grazing).
	Loss in species diversity	
	Habitat loss	
Other		
Recreational pressures	Loss of non-game species	Monitoring of waterbird numbers

Risks/limiting factors	Impacts	Mitigation measures
e.g. hunting increases in response to watering event		and diversity. Reporting of information to relevant bodies including Field and Game Association and DSE.

Appendix I: Monitoring program recommendations

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

It is recommended that an environmental monitoring plan is developed for the wetland, to ensure planned analysis and reporting of the impacts of the adopted water regime.

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 Lake Murphy.

Vegetation condition and distribution

A number of photo points have been established around Lake Murphy (Appendix J) to enable the assessment of changes in wetland condition over time (Table I1). 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 I1: Photos points for Lake Murphy (GDA94 Zone 55)

Wetland	Photo point ID	Easting	Northing	Facing
Lake Murphy	LM Photo point 1	217690.7168	6034059.504	West
	LM Photo point 2	217755.3074	6033986.459	South
	LM Photo point 3	217429.8882	6033567.519	East
	LM Photo point 4	217309.1707	6033501.969	South west
	LM Photo point 5	216366.1474	6033173.003	South
	LM Photo point 6	216816.3207	6031992.55	North west
	LM Photo point 7	217716.3679	6033132.83	West
	LM Photo point 8	217132.8782	6033130.912	West

It is also recommended that the condition and distribution of vegetation communities, including exotic species, throughout Lake Murphy 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 (Appendix E) (MDBC 2005).

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

- Index of Wetland Condition; and
- Habitat Hectares

Groundwater monitoring

Long term monitoring of groundwater within the immediate vicinity of Lake Murphy 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 to the provision of water. Monthly monitoring is recommended and snapshot assessments should incorporate the components outlined in Table I2. A database of any previous flora records has been compiled for Lake Murphy and should be updated following regular monitoring.

Table I2: Components of snapshot vegetation intervention monitoring

Component	Target	Method	Objective
Vegetation distribution	Submerged aquatic vegetation, Cumbungi, Phragmites, Lignum, Black Box and Chenopod communities	• Distribution mapping • Photo points • IWC	Habitat objectives, species/community objectives
Vegetation condition		• Photo points • IWC	Habitat objectives, 2.1
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 Lake Murphy 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 Lake Murphy and should be updated regularly following monitoring. Table I3 outlines the recommended components of waterbird monitoring that should be considered.

Table I3: Components of snapshot 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	Purple Swamphen, Hoary Headed Grebe, Black Swan Australian Shelduck	• Nest surveys (MDBC 2005)	Habitat objectives, 2.1

Fish and macroinvertebrates

It is also recommended that the response of fish and macroinvertebrates is monitored following watering as they are significant food sources for several waterbirds. Numerous surveys and records exist to provide baseline data to enable evaluation of the response to watering. A database has also been compiled of all recordings made at Lake Murphy and should be updated regularly following monitoring. Table I4 details the components to be incorporated in monitoring fish and macroinvertebrates.

Incidental observations of reptiles and amphibians should also be recorded.

Table I4: Components of snapshot 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	1.1, 1.4, species/community objectives
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. The results of this monitoring should be used to facilitate the adaptive management associated with the recommended flow regime.

Table I5 identifies elements to be considered as part of the water quality monitoring program.

Table I5 **:** 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 metre</td><td rowspan="5">Habitat objectives, species/community objectives</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 J: Photo points

LM Photo point 1

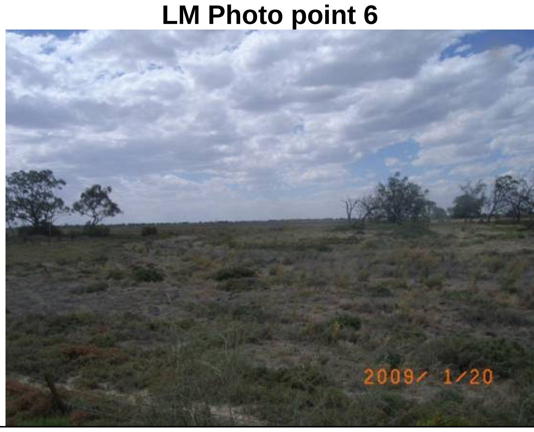
LM Photo point 2

LM Photo point 3

LM Photo point 4

LM Photo point 5

LM Photo point 6



LM Photo point 7

LM Photo point 7

NORTH CENTRAL
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