Psyche Bend Lagoon and Woorlong Wetland Environmental Water Management Plan

catchment management authority

Department of Environment, Land, Water & Planning

State Government Victoria

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Executive summary

Environmental Water Management Plans (EWMPs) have been developed for key sites in the Mallee region. The Mallee Waterway Strategy 2014-22 (Mallee CMA, 2014) covers 216 identified waterways which have been grouped into planning units according to hydrological interconnectedness and commonality of threats impacting on the waterways values; resulting in 23 Waterway Management Units. This Environmental Water Management Plan (EWMP) sets out the long-term objectives for the priority environmental values of Psyche Bend Lagoon and Woorlong Wetland.

Psyche Bend Lagoon and Woorlong Wetland WMU sub-unit (Psyche Woorlong) is located in the Robinvale Plains bioregion within the Mallee Catchment Management Authority (Mallee CMA) region 10 km south-east of Mildura and covers 1194.68 ha.

The primary use of Psyche Woorlong is for irrigation drainage disposal and it forms part of the Kings Billabong Park. Kings Billabong Park is a significant area for wildlife and regional tourism. The Mallee CMA acknowledges the ongoing use of Psyche Woorlong for irrigation drainage disposal and understands that any ecological and hydrological objectives recommended in this EWMP should consider the sites ongoing use. However, opportunities to protect the environmental values and improve conditions may be provided through environmental watering at this site.

Within Psyche Woorlong many significant species exist and both permanent freshwater and semi-permanent saline wetlands provide a range of habitats. With appropriate management, Psyche Bend Lagoon may be a suitable site for the translocation of Murray Hardyhead (*Craterocephalus fluviatilis)*, a species found in only a small number of wetlands and listed under the *Environmental Protection and Biodiversity Conservation Act.*

The whole of Psyche Woorlong has a water requirement as a floodplain complex but the focus for this plan is restricted to a target area within Psyche Woorlong of 377 ha. This target area is the extent to which environmental water is able to be managed with proposed infrastructure in place. Without infrastructure recommendations the target area does not exceed 102 ha. The target area does not encompass any private land.

The target area of Psyche Woorlong covers five out of seven wetlands that can be managed in two groups: Psyche Wetlands (#7329125081, #7329132074, #7329138072 and #7329135066) and Woorlong Wetland (#7329120065). The target area also includes areas of floodplain, beyond the mapped extent of the wetlands.

The long term management goals for Psyche Woorlong are to:

- Maintain Woorlong wetland as an open drought tolerant wetland community dominated by chenopods and Lignum.
- Maintain Psyche Bend Lagoon as a permanent saline wetland supporting habitat for wading birds and possible translocation and self-sustaining population of Murray Hardyhead.

To achieve this, ecological and hydrological objectives were designed with the consideration of short-term and longer term watering regimes.

The ecological objectives for Psyche Bend Lagoon are:

- Self-sustaining population of Murray Hardyhead following translocation.
- Extensive beds of *Ruppia* spp. in wetland.
- Provide shallow water habitat and exposure of mudflats to support foraging and resting of small waders.
- Maintain high levels of aquatic productivity.

The ecological objectives for Woorlong Wetland are:

- Healthy and productive Lignum and chenopod communities.
- Provide seasonal aquatic that supports a diverse range of small fish and frogs.
- Reduce the area of Woorlong wetland dominated by reed (Phragmites and Cumbungi) communities.
- Maintain high levels of aquatic productivity.

The optimal, minimum and maximum watering regimes for the short term goal of reducing salinity and the longer-term goals involving Murray Hardyhead introduction to Psyche Bend Lagoon are described below.

Woorlong wetland and floodplain

Inundate Woorlong wetland and floodplain to 37.5m AHD three years in every ten years. Allow water to recede naturally to expose the wetland bed. Ensure that local drainage water is diverted away from Woorlong wetland to ensure control of reeds.

The watering regime for Woorlong wetland is the optimal regime. A maximum regime has not been described, as further increased frequency and duration of watering would lead to an unacceptable salinity impact. A minimum watering regime has not been described as reduced watering frequency and duration would lead to unacceptable risk to the vegetation community and other aspects of the wetland and floodplain ecology.

Psyche Bend Lagoon

Stage 1 – Short-term regime aimed at salinity management and establishment of diverse macrophyte community

Fill Psyche Bend Lagoon to 36m AHD every year in late winter, allow water to recede naturally through late summer/spring to a minimum level of 35m AHD. Three years in ten open regulators to Murray River allowing release of water and a flush of salinity. Ensure that flush is undertaken in accordance with the operating rules for flushing events at Psyche Bend Lagoon.

Stage 2 – Subject to Murray Hardyhead reintroduction

Maintain Psyche Bend Lagoon as a permanent saline wetland, with seasonally variable water levels. Fill/top up Psyche Bend Lagoon annually in spring (August to October) to 36m AHD, allow water level to decrease through late summer/autumn to a minimum of 35m AHD exposing fringing vegetation and mudflats. Ensure that minimum water level will maintain inundation of *Ruppia spp.* beds.

Infrastructure is required to be constructed at this site to allow the efficient and effective delivery of environmental water. Detailed design is required.

Acknowledgements

This EWMP was produced by The Mallee Catchment Management Authority, with funding from the Victorian Government. The valuable contributions of Parks Victoria, Jane Roberts, Terry Hillman, other agencies and community members are also acknowledged.

1 Introduction

This EWMP has been prepared by the Mallee CMA to establish the long-term management goals of Psyche Bend Lagoon and Woorlong Wetland.

The key purposes of the EWMP are to:

- identify the long-term objectives and water requirements for the wetland, identified as a high priority by the CMA;
- provide a vehicle for community consultation, including for the long-term objectives and water requirements of the wetlands;
- inform the development of seasonal watering proposals and seasonal watering plans; and
- inform long-term watering plans that will be developed under Basin Plan requirements.

2 Site overview

2.1 Site location

The Mallee CMA region is located in the north-west of Victoria covering approximately 39,000km² with an estimated regional population of 65,000. The catchment runs along the Murray River from Nyah to the South Australian border, and as far south as Birchip and Rainbow (MCMA 2014). Major towns include Mildura, Birchip, Sea Lake, Ouyen, Robinvale, Red Cliffs and Merbein. The region is semi-arid, with an annual rainfall of around 250mm and average daily temperatures (at Mildura) ranging from 32°C in summer to 15°C in winter (MCMA 2006).

The Mallee CMA region consists of 38% of public land which is mainly national parks, reserves and large reaches of riverine and dryland state forest. The rest of the region is important for dryland farming of sheep and cereals, and irrigated horticulture (MCMA 2006).

In 2006 the Mallee CMA engaged consultants Ecological Associates to investigate water management options for the Murray River floodplain from Robinvale to Wallpolla Island. One of the major outcomes of these investigations was the development of a system of Floodplain Management Units (FMUs). These divide the floodplain into management units in which water regimes can be managed independently of another FMU. FMUs are relatively consistent in their ecological values and land uses. The Mallee CMA has used FMUs to inform planning and development of environmental water management plans to achieve more effective management of hydrologically connected systems. In addition to this the Mallee CMA has also used individual FMUs or groupings of FMUs to form Waterway Management Units (WMU) for planning within its Mallee Waterway Strategy (MCMA 2014).

The EWMP has been developed for a sub-unit of the Karadoc WMU. Karadoc covers a series of unconnected sub-units from Nangiloc to Kings Billabong. This sub-unit includes Psyche Bend Lagoon and Woorlong wetlands, and will be referred to as Psyche Woorlong for the purposes of this EWMP (Figure 1).

A regional context document has been prepared to compliment the Mallee CMA EWMPs and should be read in conjunction with this document (North, 2014).

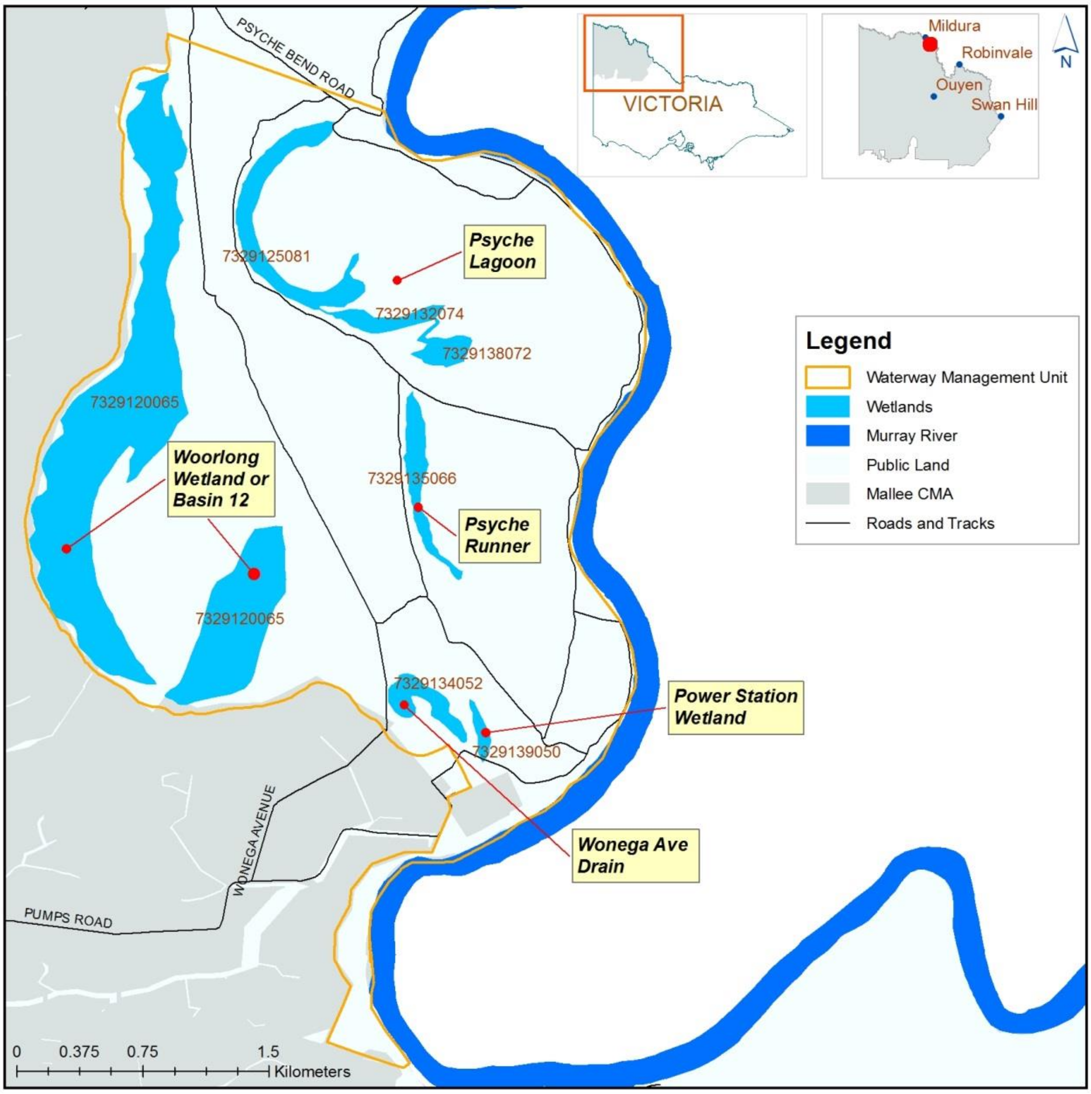


Figure 1 - Psyche Woorlong WMU Sub-unit

2.2 Catchment setting

Psyche Woorlong is located in the Robinvale Plains bioregion within the Mallee CMA region 10 km south east of Mildura. The Robinvale Plains bioregion is characterised by a narrow gorge confined by the cliffs along the Murray River, which is entrenched within older up-faulted Cainozoic sedimentary rocks. Alluvium deposits from the Cainozoic period gave rise to the red brown earths, cracking clays and texture contrast soils (Dermosols, Vertosols, Chromosols and Sodosols) this supports Riverine Grassy Forest and Riverine Grassy Chenopod Woodland ecosystems.

The bioregion has many periodically flooded wetlands, which make it generally unsuitable for development. Consequently, much of the native vegetation within the bioregion still remains, mostly as public land in state forest, the Murray River Reserve and the Hattah-Kulkyne National Park (Ecological Associates 2007).

2.4 Psyche Woorlong

Psyche Woorlong is located between river km 923 and river km 952, 25km south-east of Mildura. The floodplain is an elongate area, approximately 9 km from north to south and 2-3 km broad, with the Murray River on the eastern side. The floodplain is located 22 upstream of the Mildura Weir (Lock 11), which maintains an upstream level of 34.4 m AHD.

The Psyche Bend Lagoon and Woorlong Wetlands are of national significance and are listed under the Directory of Important Wetlands. These wetlands are located in the southern end of Kings Billabong Park, a significant conservation Park of the Sunraysia district (Bluml, 1992). The floodplain is managed within the Kings Billabong Park, with two management areas separated by the Psyche Bend Road: Kings Billabong in the north and Psyche Woorlong in the south. While the northern section of the Park is in relatively good condition, the southern end around Psyche and Woorlong wetlands is severely degraded due to salinity as a result of surrounding irrigation (SKM 2002).

Psyche Woorlong consists of two distinct areas: Psyche Bend Lagoon and Woorlong Wetlands. The Psyche Woorlong floodplain has a total area of 1,200 ha of which 377 ha is wetland (Mallee CMA 2015b). Ground elevations lie at approximately 38 m AHD on the floodplain and 50 m AHD in the surrounding terrestrial landscape.

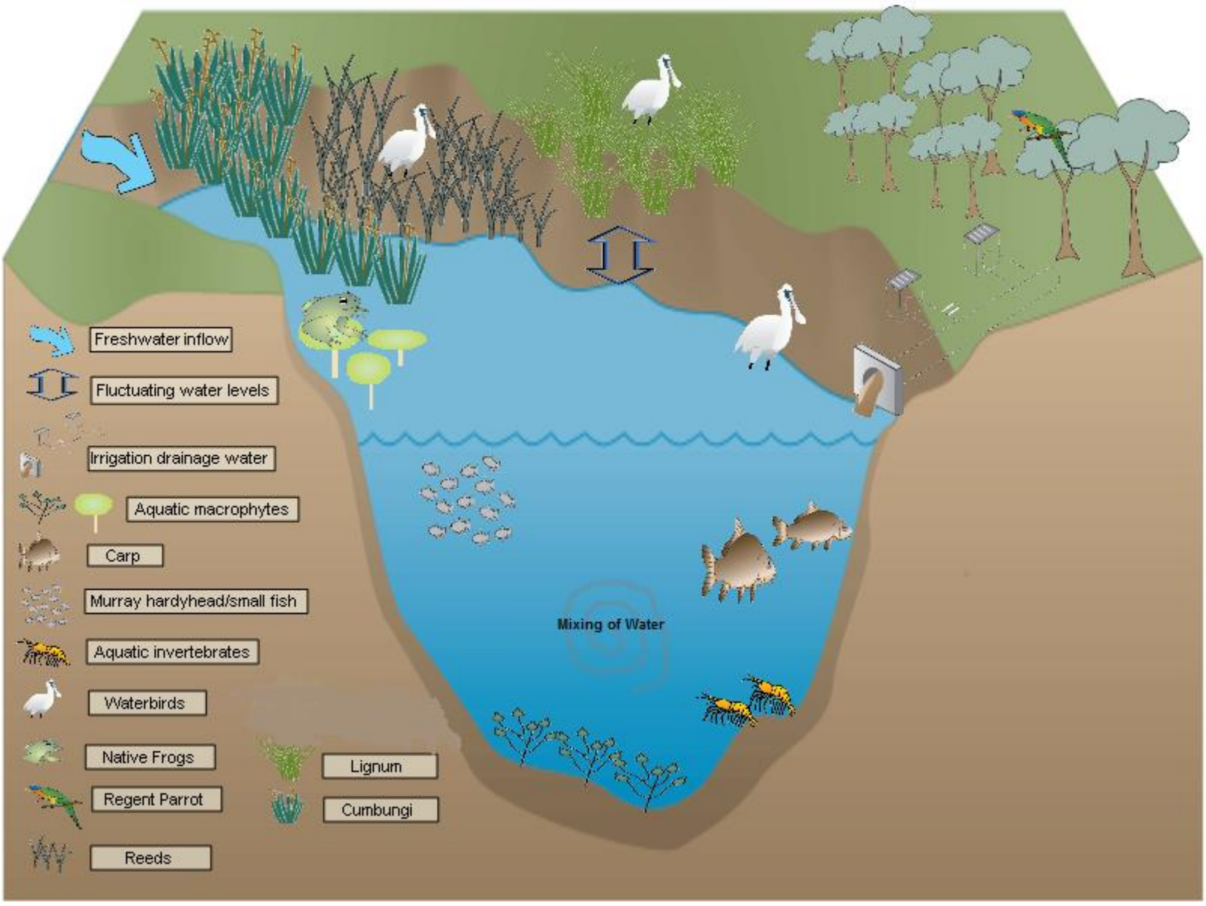
Psyche Bend Lagoon consists of six semi-permanent saline wetlands covering an area of approximately 53 hectares. These wetlands are of Psyche Bend Lagoon (#7329125081) and wetlands #7329132074, #7329138072, #7329134052 (Wonega Ave Drain), #7329139050 (Power Station Wetland) and #7329135066 (Psyche Runner). These wetlands are dominated by Lignum Shrubland and Lignum Swampy Woodland.

Woorlong Wetlands (#7329120065) are permanent open freshwater wetlands covering an area of approximately 153 ha. Vegetation communities consist of Spike-sedge Wetland, Lignum Swamp, and Lignum Swampy Woodland vegetation communities.

Psyche Woorlong is currently used for irrigation drainage disposal and this use will continue in the future. The Mallee CMA acknowledges this will be the primary use for the site going forward, however, there are opportunities to protect the sites ecological values through environmental watering and thus ecological and hydrological objectives have been set.

2.5 Conceptualisation of the site

A conceptual model has been developed for Psyche Woorlong which describes how the ecological processes and water dependent values will interact (Figure 2). The model provides a visual representation of the sites processes and components that are discussed throughout the document and represents the wetland system being targeted.



Saline irrigation drainage and groundwater discharge enter the wetland, increasing salinity levels. Freshwater inflows to the system will be delivered as environmental water to provide fluctuating water levels and reduce salinity. This flooding leads to the rapid release of nutrients from the soils, the seed banks of aquatic plants, such as Ruppia, emergence of eggs and invertebrates. This pulse in aquatic macrophytes and invertebrates provides food for Murray Hardyhead. The wetland becomes more productive as surrounding emergent vegetation benefits from periodic inundation, water levels rise and fall and increases waterbird feeding habitat.

Figure 2 - Values, threats and processes associated with the Psyche Woorlong Wetlands

2.6 Land status and management

There are many agencies and groups involved in managing Psyche Woorlong (Table 1). The site consists largely of public reserve, with a small proportion of private land used for agricultural activities (Figure 3).

Psyche Woorlong area is managed as part of the Kings Billabong Park, since implementation of recommendations in the River Red Gum Forests Investigation (VEAC 2008). Prior to 2008 the Park was managed as Kings Billabong Wildlife Reserve. Parks Victoria is the land manager. Land status is shown in Figure 3. The Lower Murray Water Authority manages the substantial irrigation water resources and infrastructure within the park. The historic pump station is operated and maintained by the Sunraysia Steam Preservation Society Inc.

Table 1 - Stakeholders for Psyche Woorlong

Group	Role
Parks Victoria	Land Manager
Mallee CMA	Regional environmental management
Department of Environment Land, Water and Planning	State level environmental water management planning, land manager, threatened species manager
Lower Murray Water	River Murray operations
Mildura Rural City Council	Local Government
Aboriginal Stakeholders	Aboriginal stakeholders. Provides assistance in planning and implementation of programs
Sunraysia Bird Observers Club, Friends of Kings Billabong	Flora and Fauna interest
Residents and visitors to Mildura area, Steam preservation Society	Social and recreational use
Victorian Environmental Water Holder (VEWH)	Environmental Water - Project Partners
Commonwealth Environmental Water Holder (CEWH)	Environmental Water - Project Partners

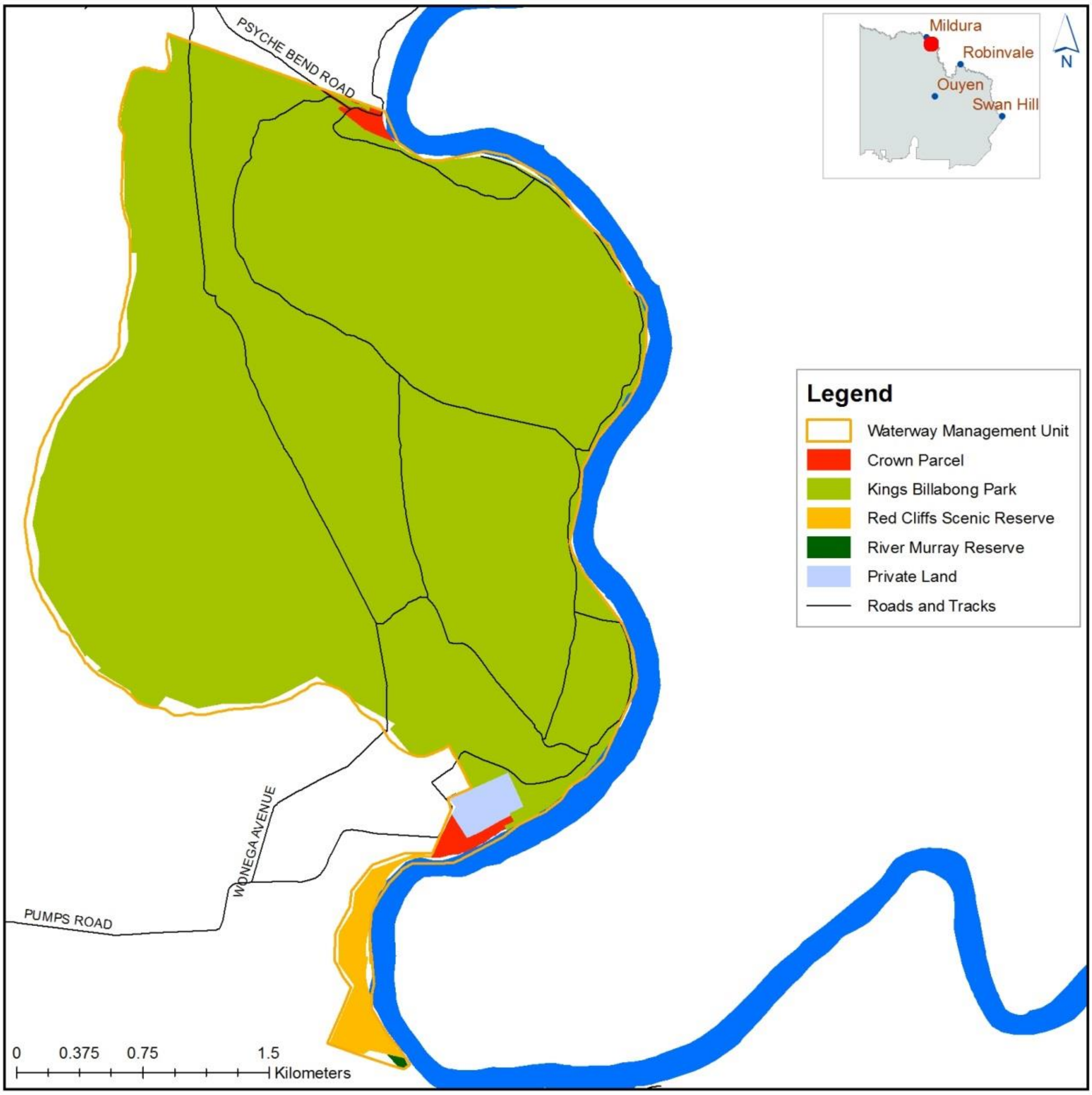


Figure 3 - Land management boundaries in Psyche Woorlong

2.7 Wetland characteristics

An overview of the main characteristics of the wetlands at Psyche Woorlong is provided in Table 2.

Table 2 - Summary of Psyche Woorlong wetland characteristics

Characteristics	Description
Name	Psyche Woorlong WMU Sub-unit
Mapping ID within area*	Psyche Bend Lagoon (7329125081) 30 ha, 7329138072 10.89 ha and 7329132074 2.9 ha Psyche Runner (7329135066) 9.2 ha Wonega Ave Drain (7329134052) 7.2 ha Power Station Wetland (7329139050) 2.2 ha Woorlong Wetlands (Basin 12) (7329120065) 116.1 ha Woorlong Drains (No Corrick ID, but part of #7329120065 in 1994 layer) 37.5 ha
Area	215.99 ha of wetlands (1194.68 ha WMU sub-unit)
Bioregion	Robinvale Plains
Conservation status	Directory of Important Wetlands in Australia
Land status	Kings Billabong Park
Land manager	Parks Victoria
Surrounding land use	Irrigated horticulture, rural township
Water supply	Regulated natural connection under influence of Lock 11 weir pool. Option to fill from drainage channel to Woorlong wetland.
1788 wetland category	Permanent Open Freshwater (5), Deep Freshwater Marsh (1), Shallow Freshwater Marsh (1)
1994 wetland category and sub-category	Permanent Open Freshwater (1), Semi-permanent Saline (6)
Wetland depth at capacity	Woorlong Wetlands >5m, Psyche Bend Lagoon >2m

*Wetland names are taken from Victorian Wetland Environments and Extent – up to 2013 wetland spatial layer, known as WETLAND_CURRENT, the numbers are based on the 1994 Wetland layer.

Psyche Bend Lagoon (#7329125081), wetlands #7329132074, #7329138072, Wonega Drain (#7329134052), Power Station Wetlands (#7329139050) and Psyche Runner (#7329135066) are classified as semi-permanent saline and cover an area of 52.99 hectares. The mapped EVCs for this area are Lignum Shrubland and Lignum Swampy Woodland.

Woorlong Wetland or Basin 12 (#7329120065) is classified as permanent open freshwater.

Locations of wetlands within Psyche Woorlong are shown in Figure 4. The classifications of wetland type differ significantly between the two spatial layers (1994 and 2013). The 1994 layer was found from field visits to be most appropriate to classify each wetland. The water regimes of the wetlands have been fundamentally changes through river regulation and irrigation drainage disposal. Recommended watering regimes are cognisant of these impacts and likely future uses.

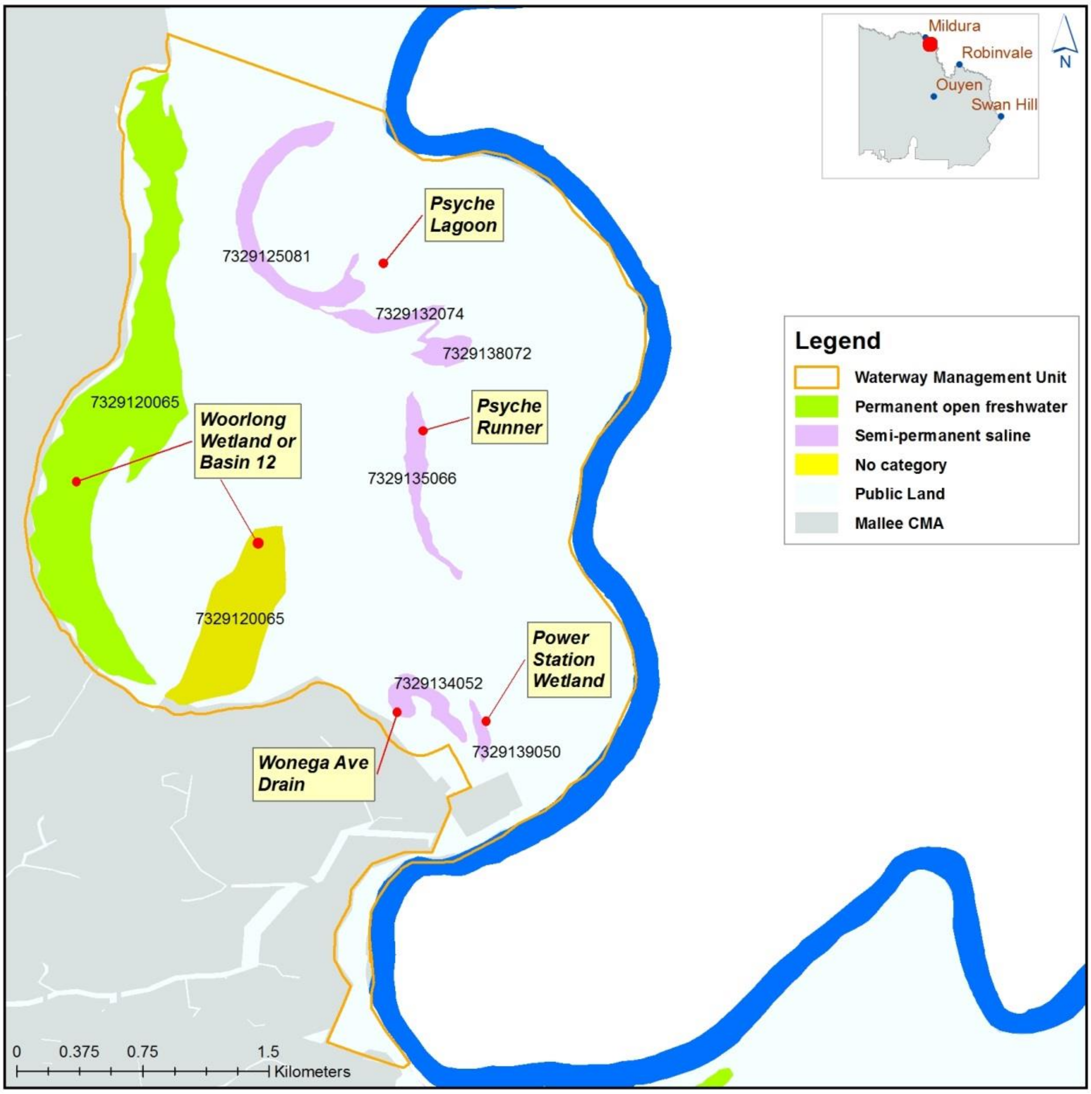


Figure 4 - Wetland locations and classification at Psyche Woorlong

2.8 Management scale

The whole of Psyche Woorlong has a water requirement as a floodplain complex but the focus for this plan is restricted to a target area within Psyche Woorlong of 377 ha, as shown in Figure 5. This target area is the extent to which environmental water is able to be managed with proposed infrastructure in place. Without infrastructure recommendations the target area does not exceed 102 ha. The target area does not encompass any private land.

The target area of Psyche Woorlong covers five out of the seven wetlands. These are to be managed in two groups: Psyche Bend Lagoon Wetlands (#7329125081, #7329132074 and #7329138072) and Psyche Runner (#7329135066); and Woorlong Wetland (#7329120065) (Figure 1). The target area also includes an area of floodplain, beyond the mapped extent of the wetlands, as shown in Figure 5.

Power Station Wetland (#7329 139050) and Wonega Avenue Drain (#7329 134052) are excluded from the target area as they are higher on the floodplain and watering them would inundate lower lying non-target areas and they are not able to be watered with the current or proposed infrastructure.

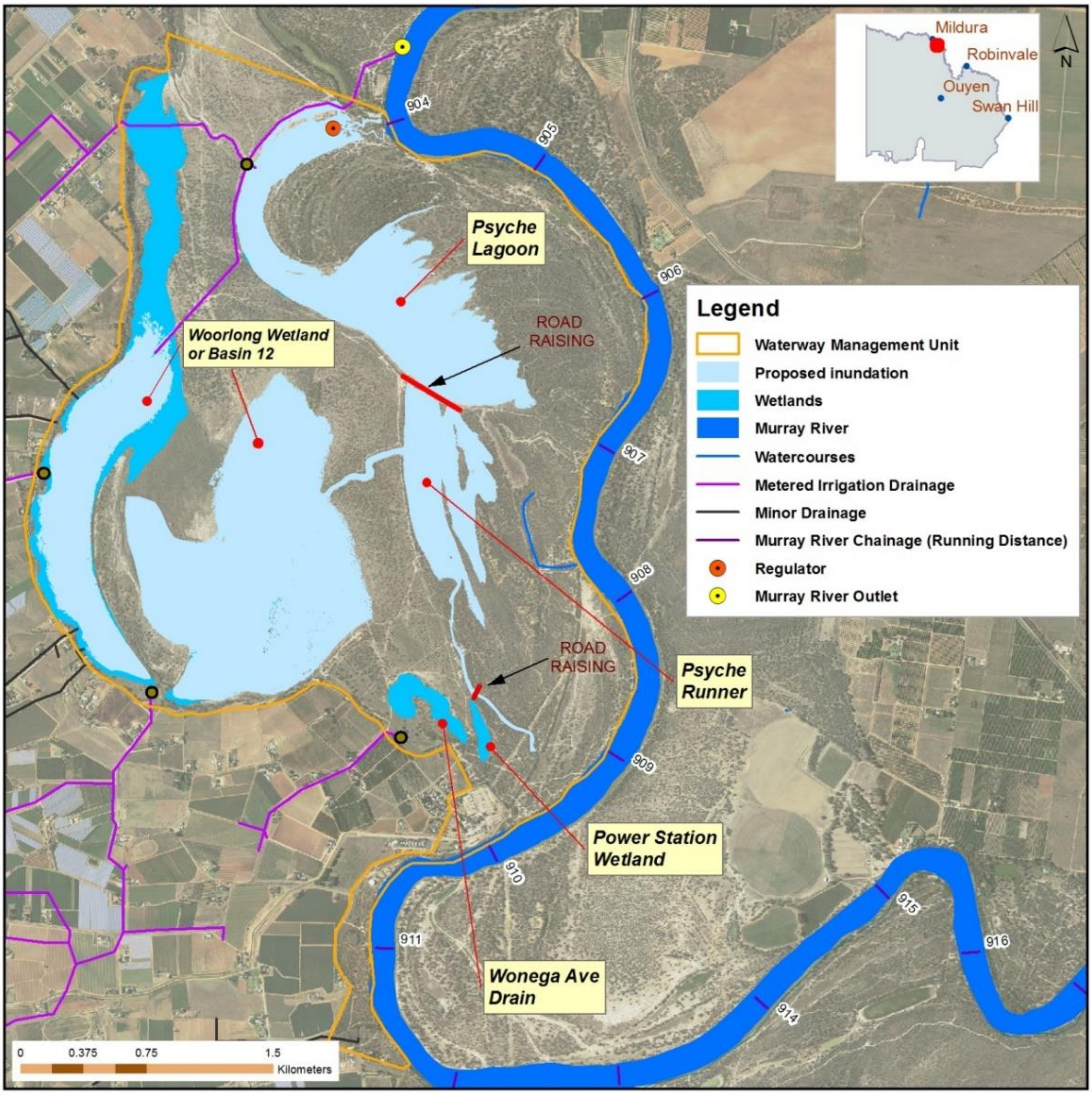


Figure 5 - Target area of Psyche Woorlong shown in light blue as proposed area of inundation

2.10 Assessment of salinity risk

The Murray-Darling Basin Ministerial Council released the Basin Salinity Management 2030 (BSM 2030) in 2015. This document builds on the Basin Salinity Management Strategy of 2001-2015 (BSMS) and provides a program of salinity management across governments to meet the Basin Salinity Target of maintaining the salinity at Morgan at less than 800 EC for 95 percent of the time. An accountable action under this plan is one that is assessed as causing a change in average daily salinity at Morgan of 0.1 EC or more by 2100. Schedule B of the Water Act (2007) requires that, if an activity causes a significant salinity effect it be treated as an accountable action. Accountable actions trigger a detailed assessment and possible entry on either of the salinity Registers (A or B).

An assessment of possible watering regimes and target areas for Psyche Woorlong was undertaken at the draft EWMP stage. The watering regimes were assessed to determine their potential impacts on salinity in the Murray River (Richardson and Currie, 2015) and (Currie and Richardson, 2016) via the mobilisation of salt. The modelling identified that the salinity pathways for Psyche Woorlong are:

- Surface water
    - Mixing of existing surface water.
    - Salt wash-off from floodplain soils.
    - Evaporative concentration of impounded waters.
    - Flushing will release surface water (and salt load) to the Murray River.
- Groundwater
    - Enhanced recharge to groundwater.
    - A rise in groundwater levels and an altered hydraulic gradient across the floodplain, relative to the baseline condition.
    - A resultant increase in groundwater flux (and salt load) to the Murray River that is related to the level and duration of watering.

The estimated potential EC impact at Morgan for the draft and recommended watering options at Psyche Woorlong are presented in Table 3. The accountable actions are highlighted in red. All watering options, except for one Woorlong Wetland option, were modelled as accountable actions.

Table 3 - Estimated potential EC impact at Morgan for proposed Psyche Bend watering options

Option	Target watering frequency		Estimated EC impact at Morgan		
			Ground water pathway	Surface water pathway	Total
Stage 1- Woorlong Wetland- short term (draft option)	Min	1 year in every 2, max 1 year interval between events	0.44	n.a	0.44
	Opt	2 years in every 3, max 6 month interval between events	0.61	n.a	0.61
	Max	Each year, maintain permanent inundation	1.45	n.a	1.45
Stage 1- Woorlong Wetland- long term (draft option)	Min	3 years in every 10[1]	0.03	n.a	0.03
	Opt	5 years in every 10	0.17	n.a	0.17
	Max	Each year	0.66	n.a	0.66
Stage 2- Psyche Bend Lagoon- short term (draft option)	Min	1 year in every 2, max 1 year interval between events	0.04	0.35	0.39
	Opt	2 years in every 3, max 6 month interval between events	0.28	0.46	0.74
	Max	Each year, maintain water for 6 months	0.95	0.70	1.65
Stage 2- Psyche Bend Lagoon- long term (draft option)	Min	5 years in every 10, max 24 month interval between events	0.11	n.a	0.11
	Opt	Each year	0.68	n.a	0.68
	Max	Each year	1.18	n.a	1.18
Psyche Bend (Stage 1)	Min	Annual inundation, no flushing	0.18	n.a.	0.18
	Opt	Annual inundation, flushing 3 years in 10	0.93	0.16	1.10
	Max	Annual inundation, flushing 2 consecutive years, twice in 10 years	0.93	0.22	1.15
Psyche Bend (Stage 2)	Min	Annual inundation, no flushing	0.93	n.a.	0.93
	Opt	Annual inundation, no flushing	0.93	n.a.	0.93

[1] Watering regime included in this EWMP for Woorlong wetlands

Option		Target watering frequency	Estimated EC impact at Morgan		
			Ground water pathway	Surface water pathway	Total
	Max	Annual inundation, flushing 2 consecutive years, twice in 10 years	0.93	0.22	1.15

2.11 Environmental water sources

The Environmental Water Reserve (EWR) is the legally recognised amount of water set aside to meet environmental needs. The EWR can include minimum river flows, unregulated flows and specific environmental entitlements. Environmental entitlements can be called out of storage when needed and delivered to wetlands or streams to protect their environmental values and health.

The Victorian Minister for Environment and Climate Change appointed Commissioners to Victoria's first independent body for holding and managing environmental water, the Victorian Environmental Water Holder (VEWH). VEWH is responsible for holding and managing Victoria's environmental water entitlements, and making decisions on their use.

Environmental Water for the study site may be sourced from the water entitlements and their agencies listed in Table 4 below. Other sources of water may become available through water trading or changes in water entitlements.

Table 4 - Summary of environmental water sources available to Psyche Woorlong*

Water Entitlement	Responsible Agency
Bulk Entitlement (River Murray - Flora and Fauna) Conversion Order 1999	Victorian Environmental Water Holder
Environmental Entitlement (River Murray – NVIRP Stage 1) 2012	Victorian Environmental Water Holder
Commonwealth environmental water holdings	Commonwealth Environmental Water Office
Donated Water	Victorian Environment Water Holder

2.12 Related plans and activities

There is a range of international treaties, conventions and initiatives, as well as National and Acts, policies and strategies that direct management of Psyche Woorlong. Those with relevance to the site and the management of its environmental and cultural values are listed in

Table 5. For the functions and major elements of each refer to the Regional Context Document (North, 2014).

Table 5 - International conservation conventions, and national and state legislation relevant to management of the target area

Jurisdiction	Legislation, agreement or convention
National	Environment Protection and Biodiversity Conservation Act 1999 (EPBC)
National (international agreements administered under the federal *EPBC Act*)	China-Australia Migratory Bird Agreement (CAMBA) Japan- Australia Migratory Bird Agreement (JAMBA)
State	Flora and Fauna Guarantee Act 1988 (FFG)
	DELWP Advisory Lists of Rare or Threatened Flora and Threatened Fauna

Psyche Bend Lagoon and Woorlong Wetland are situated within the Kings Billabong Park on the Victorian floodplain of the Murray River which is the subject of investigations in many guises. Kings Billabong was a Wildlife Reserve until it was declared the Kings Billabong Park following the River Red Gum Forests Investigation (VEAC 2008).

In 2006, Mallee CMA engaged consultants Ecological Associates to investigate water management options for the floodplain of the Murray River from Robinvale to Wallpolla Island. This investigation proposed infrastructure to enable greater inundation of the target area at Psyche Woorlong which is outlined as part of this plan.

Psyche Woorlong is within the area covered by the Mallee CMA Frontage Action Plan (FAP) for Nyah to Robinvale (MCMA 2003). Parks Victoria in conjunction with the Mallee CMA has invested significant resources into the Kings Billabong area in recent years in the form of regulator installation, cultural heritage management planning, operational plans and environmental management plans. On-ground works such as track upgrading, pest plant and animal control, and improved signage have been implemented to decrease recreational pressures on the floodplain. There is potential to attract future funding and works through the FAP project.

The Mallee Waterway Strategy 2014 - 2022 (Mallee CMA, 2014) sets regional goals for waterway management that align with the Mallee Regional Catchment Strategy's broader objectives, identifies high value waterways, details strategic work programs for priority waterways, identifies the roles and responsibilities of regional stakeholders and establishes principles to guide the implementation. Under this strategy Psyche Bend and Woorlong Wetland are listed as high priority wetlands.

The Regional Context Document for Environmental Water Management Plans; Mallee CMA Region (Sunraysia Environmental, 2014) provides background context for the region, outlines significant wetlands and rivers, sources of environmental water and policy, legislative and planning frameworks.

Salinity risk management

Psyche Woorlong has been the subject of various salinity studies and management plans due to the use of these basins for irrigation disposal. Investigations have also been conducted into the effect of irrigation drainage on ground water levels surrounding the basins.

A Preliminary Salinity Impact Assessment study (SKM 2014) was undertaken to investigate environmental watering proposals at Psyche Woorlong. This study tested three phases of watering regimes, focussing on surface water salinity processes and groundwater salinity processes. Scenarios included base case (typical conditions), emptying of Psyche Bend Lagoon from 34.4m AHD, inundation of Psyche Bend Lagoon to 36m AHD, inundation of Woorlong Wetlands to 37.1m AHD, and discharge of salt from Psyche Bend lagoon into the Murray River @ 7,000 and 13,000 ML/day flow.

This preliminary investigation estimated that the salinity impacts at Morgan due to environmental watering scenarios at these sites, to be between 0.01 EC and 0.2 EC (SKM 2014). As the salinity impacts of the proposed watering actions at Psyche Woorlong exceeded 0.1 EC at Morgan, they were considered an accountable action under the BSMS strategy, necessitating a further salinity impact assessment, undertaken by CDM Smith in 2015 (Richardson and Currie, 2015).

Investigation of Psyche Bend as a Murray Hardyhead translocation site

Psyche Bend Lagoon is one of a number of saline wetlands in the Mallee CMA region that are being investigated for their potential to support translocated populations of the Federal *Environment Protection and Biodiversity Conservation Act 1999* listed Murray Hardyhead (*Craterocephalus fluviatilis*). A National Recovery Plan for the Murray Hardyhead aims to identify threats to the species and determine recovery objectives and actions to ensure the long-term survival of Murray Hardyhead (Backhouse, Lyon and Cant, 2008). Any activities involving Murray Hardyhead at Psyche Bend will be undertaken in line with this Recovery Plan.

The Psyche Bend Lagoon Scheme

Until 1995, irrigation drainage water entered Woorlong Wetland (Basin 12) and passed through Psyche Bend Lagoon before flowing into the Murray River. High levels of drainage from surrounding irrigation had led to an increase in ground water levels and subsequent groundwater intrusion in Psyche Bend Lagoon. The drainage water leaving Basin 12 would mix with the highly saline ground water in Psyche Bend Lagoon resulting in frequent discharges of saline water into the Murray River immediately upstream of the Lower Murray Water irrigation pumps (RPS Aquaterra 2013).

The Psyche Bend Lagoon Scheme was established to divert irrigation drainage around Psyche Bend Lagoon, using a constructed pipeline, directly into the Murray River. In conjunction with the drainage scheme, Psyche Bend Lagoon is flushed when river levels are high enough, to remove saline groundwater from the system. The aim of the scheme is to improve the health of the Lagoon by flushing salt from it and disposing of it to the Murray River in a way that has low salinity impacts downstream (RPS Aquaterra 2013).

Flushing is undertaken on river flows of greater than 35,000ML/day. When these flows occur the gates connecting Basin 12 to Psyche Bend Lagoon, and to the Murray River are opened to allow inflow. Flows of this magnitude are required to dilute the highly saline ground water in the lagoon to reduce salinity impacts downstream (RPS Aquaterra 2013).

Investigation into options for control of reeds at Psyche Woorlong

Ecological Associates (2016) completed an investigation to determine the factors driving the spread of Cumbungi and other reeds at Psyche and Woorlong wetlands and potential control measures. This EWMP incorporates some of the recommendations for the management of Cumbungi at Psyche and Woorlong, and in particular the need to have a semi-permanent water regime at Woorlong and supporting a more permanent water regime at Psyche Bend Lagoon.

4 Hydrology and system operations

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

The target area for Psyche Woorlong is located on the Victorian floodplain of the Murray River (chainage 904 km to 910). The Mildura gauge (#425010) is located downstream of the target area.

4.1 Hydrogeology

Hydrostratigraphy

The main floodplain aquifer in the Psyche Woorlong area is the Channel Sands, a 10 to 15 m thick band of coarse grained sands, which is overlain by the finer grained Coonambidgal Formation, up to 5 m thick. The Channel Sands aquifer directly overlies the Parilla Sand aquifer, which hosts a regionally extensive groundwater flow system (Richardson and Currie, 2015).

Groundwater levels and flow

Groundwater level data from twelve groundwater wells (10 in the Channel Sands aquifer and 2 within the deeper Parilla Sand aquifer) was analysed by CDM Smith in 2015. Groundwater levels within the Channel Sands aquifer were shown to be generally 2 to 5 m below ground level across the floodplain, and responsive to changes in the height of water in the lagoon. For example, nearby groundwater rose by around 0.9 m following environmental watering, resulting in an increase in the groundwater level gradient across the floodplain towards the River. As water levels declined, several nearby bores completed in the Channel Sands aquifer fell by around 0.2 to 0.3 m, following a time lag of several days. Groundwater levels in bores located more than 1,000 m from the site did not respond to the change in water level, and groundwater levels in the Parilla Sand aquifer remained static (Richardson and Currie, 2015).

The available data for a 2014 watering event suggests the interaction between groundwater and the Murray River is not significantly affected by holding water in Psyche Bend Lagoon. It is likely that losses to the shallow aquifer will flow towards the River and towards the lower lying parts of the floodplain where groundwater will discharge by evapotranspiration. Groundwater levels are slightly higher in the Parilla Sand than in the Channel Sands aquifer, suggesting groundwater has the potential to flow up into the floodplain aquifer from the deeper regionally extensive Parilla Sand aquifer (Richardson and Currie, 2015).

Groundwater salinity

Groundwater EC values were logged before, during and following the 2014 discharge event (CDM Smith, 2015). Groundwater salinity was generally between 30,000 and 60,000 EC within the Channel Sands aquifer. The salinity of groundwater within the Parilla Sands aquifer was within the range of 50,000 to 60,000 EC, which is at the higher end of the range of salinity values for the Channel Sands aquifer.

Groundwater salinity was found to be lower than that measured in the base of Psyche Bend Lagoon (greater than 150,000 EC), suggesting further concentration of salts has occurred within with lagoon (perhaps prior to filling when there was less water in the lagoon). It is also possible that the salt store in the shallow aquifer is also stratified and that very high groundwater salinity exists below the base of Psyche Bend, feeding the store of very saline water within the lagoon (Richardson and Currie, 2015).

Surface water-groundwater interactions

Psyche Bend Lagoon

When Psyche Bend is full the groundwater levels are generally slightly lower than the lagoon water level and so water may be lost from into the surrounding aquifer, especially towards the east and south. When the lagoon has been drained, then it is likely groundwater will flow into it, especially from the west. Flow of groundwater into Psyche Bend has been observed by the Mallee CMA. Groundwater inflow will only cease when the water level in Psyche Bend Lagoon is greater than the surrounding groundwater elevations, say at a height of around 35.5m AHD.

However, water level data shows that groundwater levels fell only slightly in a small number of bores following the start of the 2014 discharge event. This seems to indicate that the connection between Psyche Bend and the aquifer is restricted and that changes in Psyche Bend water levels over small time scales where the water level returns to a longer term equilibrium may not produce significant change in the shallow groundwater. The cumulative impact of successive watering events may see greater changes to groundwater levels due to filling and release of water from PBL (Richardson and Currie, 2015).

Murray River

Telfer et al. (2004) indicated that Psyche Woorlong is located along a losing reach based on NanoTEM survey (an in-stream geophysical survey); that is, River water flows into the adjacent shallow aquifer. However, the NanoTEM data (Telfer et al., 2004) also indicate a localised less resistive zone adjacent to Psyche Woorlong that may indicate that the near River aquifer is more saline in this area, suggesting local gaining conditions. This is consistent with the Aerial Electromagnetic (AEM) survey data (presented by SKM, 2014) that indicates groundwater salinity near the River tends to be higher in the Psyche Woorlong area. Lack of River water level data near Psyche Woorlong hampers a detailed analysis of interaction between the River and floodplain aquifer (Richardson and Currie, 2015).

4.2 Wetland hydrology, water management and delivery

Pre-regulation (Natural)

Under natural conditions, flow is understood to have been strongly seasonal, with median daily discharge highest in spring and lowest in autumn (Figure 6) (Ecological Associates 2007). Prior to river regulation, floodplain inundation would have occurred more frequently than under currently regulated conditions. In order to inundate low areas of floodplain and many wetlands, the flows would have needed to be 20,000 to 60,000 ML/d. These flow levels would have occurred more often and with longer duration than under the current baseline conditions (Ecological Associates 2007). This is supported by the recent spells analysis by Gippel (2014) for natural and baseline flows downstream of Euston (Figure 7)

Post-regulation (Baseline)

With the effects of major storages and river regulation on the Murray River, the frequency, duration and magnitude of most flood events have decreased significantly compared to natural conditions (Figure 7). Since 1922, 13 weirs and lock across the Murray River have been constructed. River regulation and increased consumptive water use have reduced overbank flows important for water-dependent flora and fauna (Sunraysia Environmental 2008).

Under regulated conditions water would initially enter the floodplain through Psyche Bend Lagoon before moving through shallow runners to Woorlong Wetland and draining into the deepest area of this basin. At higher water levels water would spread further through the Woorlong Wetland and eventually reach Lignum (*Muehlenbeckia florulenta*) stands higher on the floodplain. Some of the floodplain creeks may have been modified to facilitate saline irrigation drainage disposal. Water levels in Psyche Bend Lagoon are now regulated to prevent saline water reaching the Murray River during periods of low flow (Ecological Associates 2007b).

Woorlong Wetland, or Basin 12, sits on the outer edge of the floodplain and is used as an irrigation drainage basin. The flood runners which enter Woorlong Wetland from the south are now disconnected from the Murray River by natural and constructed blockages (Ecological Associates 2007b). The basin receives water from the Red Cliffs Pumped Districts and also receives inflows of stormwater from the Red Cliffs urban area (SKM 2005). This wetland used to be subject to permanent inundation but with improved irrigation efficiency and a decline in discharges the wetland is now only inundated under very high river flows (Ecological Associates 2007b). The basin may have covered an area of 360 ha in the past but the inundation area is now only about 68.6ha, ponding on the western side (SKM 2005).

Since 1996, irrigation drainage from Woorlong Wetland has bypassed Psyche Bend Lagoon (Ecological Associates 2007b). Psyche Bend Lagoon is subjected to groundwater intrusion as a result of a perched water table and has been isolated from the Murray River through installation of a regulator to prevent uncontrolled release of saline groundwater into the river. Sunraysia Community Salinity Working Group (1991, cited in SKM 2002) stated that maintaining low level ponding in the lagoon may lead to a lowering of the regional watertable.

In fact, a lowering of the ground water table has occurred, but this is due to improved irrigation practices, changes in crop types, drying of cropped areas and a drying climate. A long-term decline in ground water levels of about 3m has been observed. The regional table is currently below 34m, which is lower than Murray River level (FSL 34.4m) at Lock 10 (MCMA 2013).

The seasonal distribution of flows in this section of the Murray River shows that, despite a reduction in discharge, the river retains the same annual pattern of higher flows in Winter and Spring with lower flows in Summer and Autumn (Figure 6).

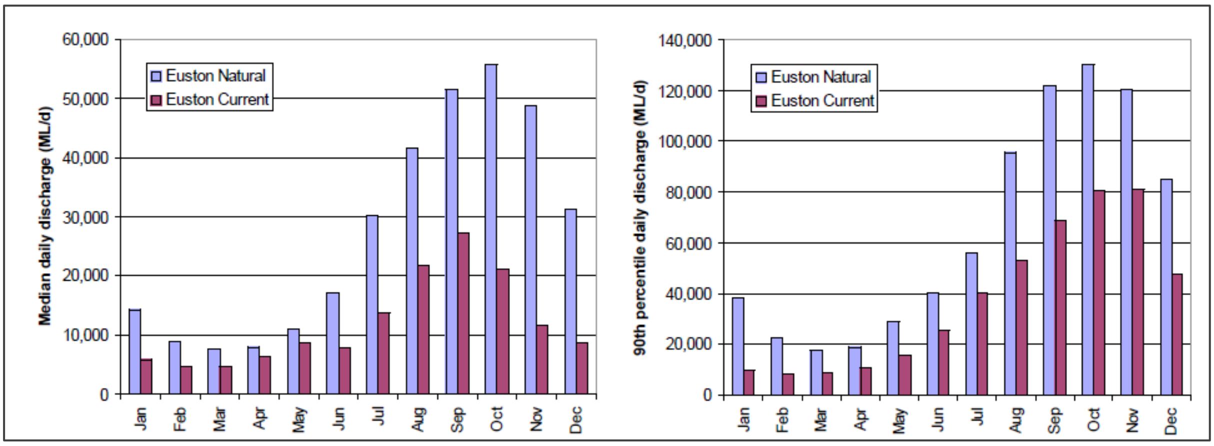


Figure 6 - Distribution of median flows and 90th percentile flows for each month in the River Murray through Euston Weir for natural and current (baseline) conditions. Source: derived from MDBC MSM-Bigmod 109-year data (Ecological Associates 2007b)

Changes to frequency of wetland inundation at Psyche Woorlong

The commence to flow rates for the wetlands, measured in ML/day, downstream of Euston Weir or upstream of Mildura weir for the wetlands at Psyche Woorlong are:

- Psyche Bend Lagoon – currently at Lock 11 Weir pool height of 34.4m AHD
- 170,100 Woorlong Wetland
- As Psyche bend is currently connected to the Murray River it is unnecessary to model the natural and baseline flows.

Spells analysis undertaken by Gippel (2014) was consulted to better understand the frequency of inundation of the Woorlong wetlands under post-regulation conditions (Figure 7). The percentage of years with the threshold event 170,100 ML/day from pre-regulation to post-regulation (baseline) have significantly reduced, and the durations of these events are also significantly reduced. The interval between events has also increased. This is shown in Table 6.

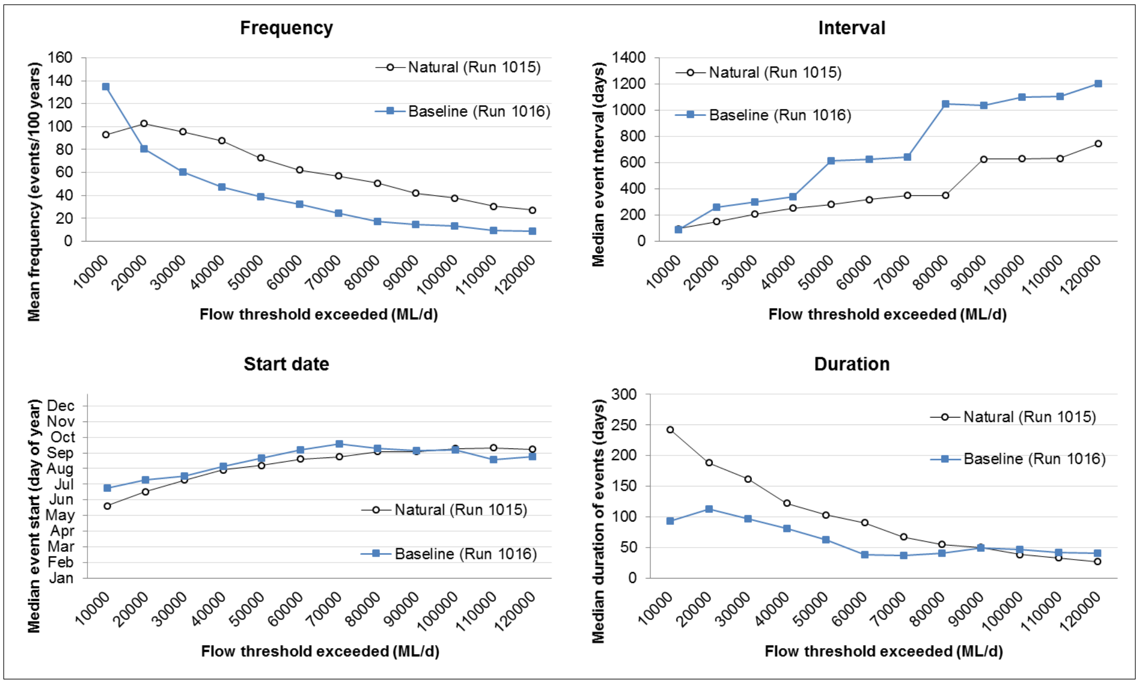


Figure 7 - Comparison of statistical properties of events at Euston under the natural and baseline modelled flow scenarios, over a 114 year period (Gippel 2014)

Table 6 - Modelled natural and baseline flows for a flow threshold of 170,100 ML/day downstream of Euston

Natural (N)/ Baseline (B)	Threshold ML/day	Frequency Mean (/10yrs)	Median Interval (50% of events are less than)	Median Duration (50% of events are shorter than)	Median Event Start date	Percentage of years with Event
N	170,100	6.1	4976	34	3rd Sept	5%
B	170,100	2.6	8136	51	31st Aug	2%

4.3 Previous environmental watering

Management intervention began at Psyche Woorlong with salt flushing events in summer 2010/11, autumn 2012 and spring 2012 to reduce salt loads from Psyche Bend Lagoon. This was undertaken in accordance with agreed protocols requiring river flows of greater than 35,000 ML/day. When 35,000 ML/day is achieved, the gates connecting Psyche Bend Lagoon with Woorlong Wetland and the Murray River are opened to allow inflow (RPS Aquaterra 2013). Analysis of data from these flushing events showed a correlation between the frequency of flushing events and a reduction in salt loads. In one year between the April 2011 and March 2012 events, salt loads increased significantly due to the mixing of the stratified waterbody, spreading the bottom hypersaline layer throughout the water column. Whereas two flushing events within five months of each other (May and October 2012) reduced salt loads by half. Refer to Table 7 and Table 8.

Table 7 - Salt loads trends for the flushing surveys

SURVEY DATE	Lagoon Elevation (mAHD)	SKM		PRS AQUATERRA	
		Salt load estimate (tonne)	Volume in store (ML)	Salt load estimate (tonne)	Volume in store (ML)
January 2011 (mid-event survey)	36.15	8,070**	990	8,701*	1,115
April 2011 (post flushing survey)	35.27	5,670	315	6,981*	335
March 2012 (Pre-flushing survey)	34.45	5,244	-	7,468*	110
May 2012 (post flushing survey)	34.8	3,709	110	5,219*	189
October 2012 (post flushing survey)	34.77	-	-	4,363	183

*Recalculation using RPS hypsographic model and salt concentration survey data from MCMA and LMW.

**Calculated as pre-flush salt load of 7950 t, plus 120 tonnes of salt introduced from Murray River (SKM, 2011)

Table 8 - Salt loads export for each flushing event

Flushing Event	Flushing Dates	Duration (days)	Estimated salt load exported (tonnes)
Summer 2010/11	17 December 2010 – 4 April 2011	110	1,720
Autumn 2012	29 March 2012 – 15 May 2012	48	2,249
Spring 2012	24 August 2012 – 9 October 2012	47	8,56
			4,825

In April 2014, watering occurred at Psyche Woorlong, but this time water was held in the wetland followed by managed discharge to the Murray River in August 2014, three months after inundation. Through consultation with discharge operations groups the discharge event was actively managed to maintain Murray River salinity within acceptable salinity targets (locally for the Lower Murray Water off-take as well as Basin Plan targets) (CDM Smith 2014).

The aim of this flushing event was to:

- reduce salt loads from the wetlands;
- improve the health of the wetlands and floodplain vegetation;
- provide habitat, feeding and breeding opportunities for fauna; and
- increase the abundance, distribution and diversity of native wetland species in the study area.

During this event the mass of salt exported during discharge was monitored and indicated that the river salinity was maintained within or below the 200—to 300 EC threshold that was set by Lower Murray Water. The mass of salt stored within Psyche Bend Lagoon following the discharge increased from 3,843 tonnes to 4,967 tonnes (Table 9), due to the mixing of layers within the waterbody.

Table 9 - Summary of salt store in Psyche Bend Lagoon

Salinity survey date	Psyche Bend Lagoon water elevation (mAHD)	Salt store (tonnes)
2 July 2014	35.5	3,358
30 July 2014	34.3	730
7 August 2014	34.6	3,843
8 October 2014	35	4,967

This indicates that implementing an environmental watering program through regular managed flushing events reduces the risk of salinity spikes during high natural flows.

The conceptualisation shown in Figure 8 (CDM Smith, 2014) describe the salt mobilisation processes pre-discharge conditions and post-discharge conditions for the 2014 discharge event.

Coinciding with the inundation of Psyche Bend Lagoon, 353ML of water was pumped into Woorlong Wetland. The aim of this environmental watering was to reduce the salt levels in the wetland and improve the health of the surrounding vegetation.

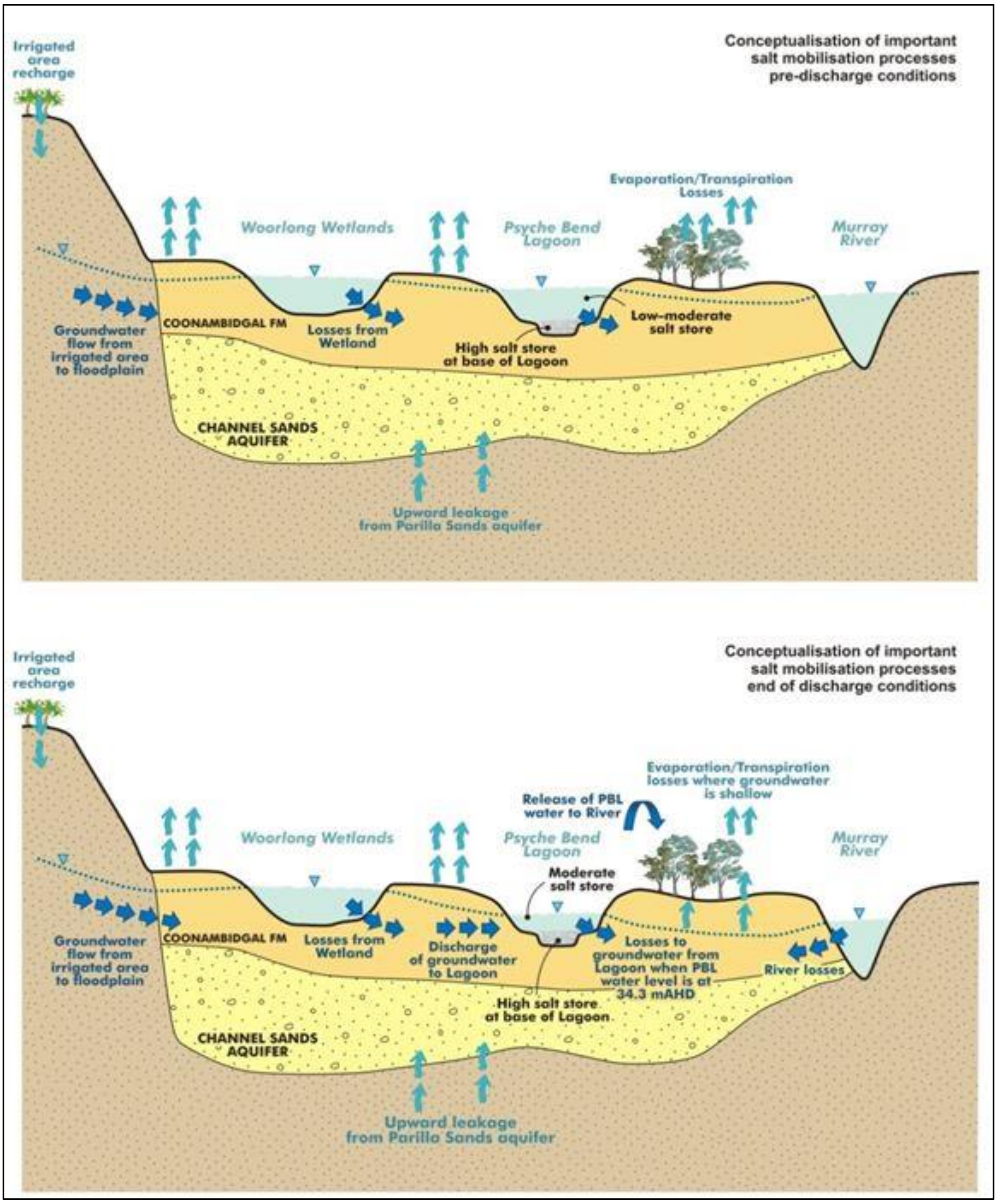


Figure 8 - Conceptualisation of important salt mobilisation processes pre-discharge and post-discharge conditions at Psyche Bend Lagoon (CDM Smith, 2014)

5 Water dependent values

5.1 Environmental values

Wetlands and waterways on the floodplain are a vital component of the landscape which support a vast array of flora and fauna which may vary greatly with the type of waterway. The habitat provided by vegetation communities around wetlands is essential for maintaining populations of water dependent fauna species. Other ecological functions provided by floodplain complexes include water filtration, slowing surface water flow to reduce soil erosion, flood mitigation and reducing nutrient input into waterways. Protecting the ecological functioning of wetlands ensures these vital services are maintained.

Listings and significance

Fauna

Psyche Bend Lagoon and the Woorlong wetland are located within the Kings Billabong Park, an area that provides habitat for a large range of fauna. The list of species recorded at Kings Billabong Park includes five species of frogs (three of which have been recorded at Psyche Woorlong) including the EPBC listed Growling Grass Frog (*Litoria raniformis*) as well as seventeen reptile species including all three species of turtles that occur in the region (SKM 2002). Of special interest and responsibility are the water dependent species listed in legislation, agreements or conventions (Table 10). A full list of all fauna recorded at Kings Billabong Park, which may be found at Psyche Woorlong is provided in Appendix 1.

Table 10 – Listed water dependent fauna recorded at the Kings Billabong Park and recorded at Psyche Woorlong

Common Name	Scientific Name	Type	EPBC status	FFG	DELWP Advisory List status	Recorded at Psyche Woorlong (No of records)
Australasian Shoveler	Anas rhynchotis	B			V	1
Baillon's Crake	Porzana pusilla	B		L	V	
Blue-billed Duck	Oxyura australis	B		L	EN	
Broad-shelled Turtle	Macrochelodina expansa	R		L	EN	
Bush Stone-curlew	Burhinus grallarius	B			EN	
Brown Tree-creeper*	Climacteris picumnus victoriae				NT	3
Carpet Python*	Morelia spilota metcalfei	R		L	EN	
Caspian Tern	Hydroprogne caspia	B		L	NT	6
Crimson-spotted Rainbowfish	Melanotaenia fluviatilis	F		L	DD	
Eastern Great Egret	Ardea modesta	B		L	V	2
Freckled Duck	Stictonetta naevosa	B		L	EN	4
Freshwater Catfish	Tandanus tandanus	F		L	EN	
Golden Perch	Macquaria ambigua	F		L	V	
Growling Grass Frog	Litoria raniformis	A	V	L	EN	
Hardhead	Aythya australis	B			V	2
Intermediate Egret	Ardea intermedia	B		L	CR	
Little Bittern	Ixobrychus minutus dubius	B		L	EN	
Little Egret	Egretta garzetta	B		L	EN	

Common Name	Scientific Name	Type	EPBC status	FFG	DELWP Advisory List status	Recorded at Psyche Woorlong (No of records)
Musk Duck	Biziura lobata	B			V	5
Nankeen Night Heron	Nycticorax caledonicus	B			NT	
Pied Cormorant	Phalacrocorax varius	B			NT	1
Regent Parrot*	Polytelis anthopeplus monarchoides	B	V	L	V	
Royal Spoonbill	Platalea regia	B			V	
Silver Perch	Bidyanus bidyanus	F		L	CR	
Unspecked Hardyhead	Craterocephalus stercusmuscarum fulvus	F		L	DD	
Whiskered Tern	Chlidonias hybridus	B			NT	
White-bellied Sea-Eagle	Haliaeetus leucogaster	B		L	V	1

Legend

Type: Invertebrate, Fish, Amphibian, Reptile, Bird, Mammal

EPBC status: EXtinct, CRitically endangered, ENdangered, VUlnerable, Conservation Dependent, Not Listed

FFG status: Listed as threatened, Nominated, Delisted, Never Listed, Ineligible for listing

DELWP status: presumed EXtinct, Regionally Extinct, Extinct in the Wild, CRitically endangered, ENdangered, Vulnerable, Rare, Near Threatened, Data Deficient, Poorly Known, Not Listed

*Species are included as water dependent due to habitat requirements.

The list includes species are considered water-dependent because they forage or nest in or over water, or require flooding to trigger breeding and fledging. This includes the Carpet Python (*Morelia spilota metcalfei*), Brown Tree-creeper (*Climacteris picumnus victoriae)* and the Regent Parrot (*Polytelis anthopeplus monarchoides)* that are indirectly dependent on water.as they require mature riparian trees for shelter and nesting.

Murray-Darling Rainbow Fish (*Melanotaenia fluviatilis*) is a small fish, up to 90mm long through frequently less than 70 mm. It prefers slow flowing rivers, wetlands and billabongs. It is a schooling fish that consumes invertebrates as well as filamentous algae. Threats include predation of adults by Redfin Perch and of larvae by Eastern Gambusia; as well as loss of aquatic vegetation which is required for spawning sites and shelter (Lintermans, 2007).

The Un-specked Hardyhead is a small fish, up to 78 mm long, though usually between 50 – 60 mm. It is found along the edges of large, slow-flowing, lowland rivers, as well as lakes, backwaters and billabongs. It prefers slow-flowing to still water with aquatic vegetation and a substrate of sand, gravel or mud. It is usually found in schools and is carnivorous, feeding on small insects and microcrustaceans. Threats include salinisation (through its impacts on aquatic invertebrate populations and vegetation structure) as well as habitat degradation, cold water pollution and introduced fish such as Redfin Perch and Eastern Gambusia (Lintermans, 2007).

The Growling Grass Frog is listed under the EPBC Act as Vulnerable and the FFG Act as Threatened. The Growing Grass Frog is usually found in among vegetation within or at the edges of permanent or ephemeral wetlands or slow flowing rivers and streams. In disturbed areas it can be found in farm dams and irrigation channels (Pyke, 2002). Preferred sites generally have a large proportion of vegetation that is emergent, submerged and floating (Clemann and Gillespie, 2012). During the winter individuals may shelter under cover close to the water such as rocks, logs and vegetation (Pyke, 2002). It is a generalist carnivore, prey species include invertebrates and tadpoles. Breeding is triggered by flooding of wetlands and floodplains during spring and summer (Clemann and Gillespie, 2012).

Psyche Bend Lagoon is a semi-permanent saline wetland, meaning that it may be considered as a translocation site for the EPBC listed Murray Hardyhead. The Mallee CMA have incorporated the need for a reduction in EC levels into the long-term hydrological objectives and estimate a 10-year management plan would provide suitable conditions for the translocation of the Murray Hardyhead into Psyche Bend Lagoon.

Murray Hardyhead

Psyche Bend Lagoon is a saline wetland in the Mallee region being monitored as a possible translocation site for the State and Commonwealth listed Murray Hardyhead (*Craterocephalus fluviatis*). This increases the conservation significance of the site and salinity levels should be managed for persistence of Murray Hardyhead.

Murray Hardyhead is considered to be critically endangered in Victoria. Hardyhead was once abundant throughout its range but has suffered a dramatic decline. due to altered flow regimes and drought. These factors have led to reduced connection between the Murray River and floodplain wetlands and drying of some lake habitats (Lintermans 2007). Altered flow regimes and drought have also impacted on water quality in waterways that historically supported Murray Hardyhead (Ellis 2013), increasing salinity and degrading habitat (Lintermans 2007). Introduced species such as Eastern Gambusia and Redfin Perch also impact on Murray Hardyhead through competition and predation (Ellis 2013).

Murray Hardyhead generally persist in waters with elevated salinity (ranging from approximately 1,000 to 110,000 EC) and with submerged vegetation. Backhouse et al. (2008) states that it is not clear if this indicates a preference for saline habitats or if it is due to the exclusion of less salt tolerant species which compete or prey on Murray Hardyhead.

Salt tolerant Ruppia is often a key aquatic macrophyte in saline wetlands where Murray Hardyhead are found. Zooplankton is the main source of food for Murray Hardyhead and some of these micro-crustaceans also rely on Ruppia for habitat. A reduction in inflows also has a detrimental effect on macrophyte communities reducing feeding and breeding habitat for Hardyhead. As an annual species, Murray Hardyhead relies heavily on successful recruitment each year. Ellis (2006, cited in Ellis 2010) states that this means even short-term changes which have a negative ecological impact on fish could have a significant effect on the long-term viability of Murray Hardyhead populations. Environmental watering on an annual basis is listed as a key management action for the long-term preservation of Murray Hardyhead populations (Backhouse et al. 2008).

Vegetation Communities

Within the target area of Psyche Woorlong are a range of water dependent Ecological Vegetation Classes (EVCs) as shown in Figure 9. The conservation status of each of the represented EVCs is shown in Table 11. The three most extensive EVCs are dominated by Lignum: (#104) Lignum Swamp, (#823) Lignum Swampy Woodland and Lignum Shrubland (#808). These EVC's are listed as vulnerable, depleted and least concern, respectively, within the Robinvale Plains bioregion.

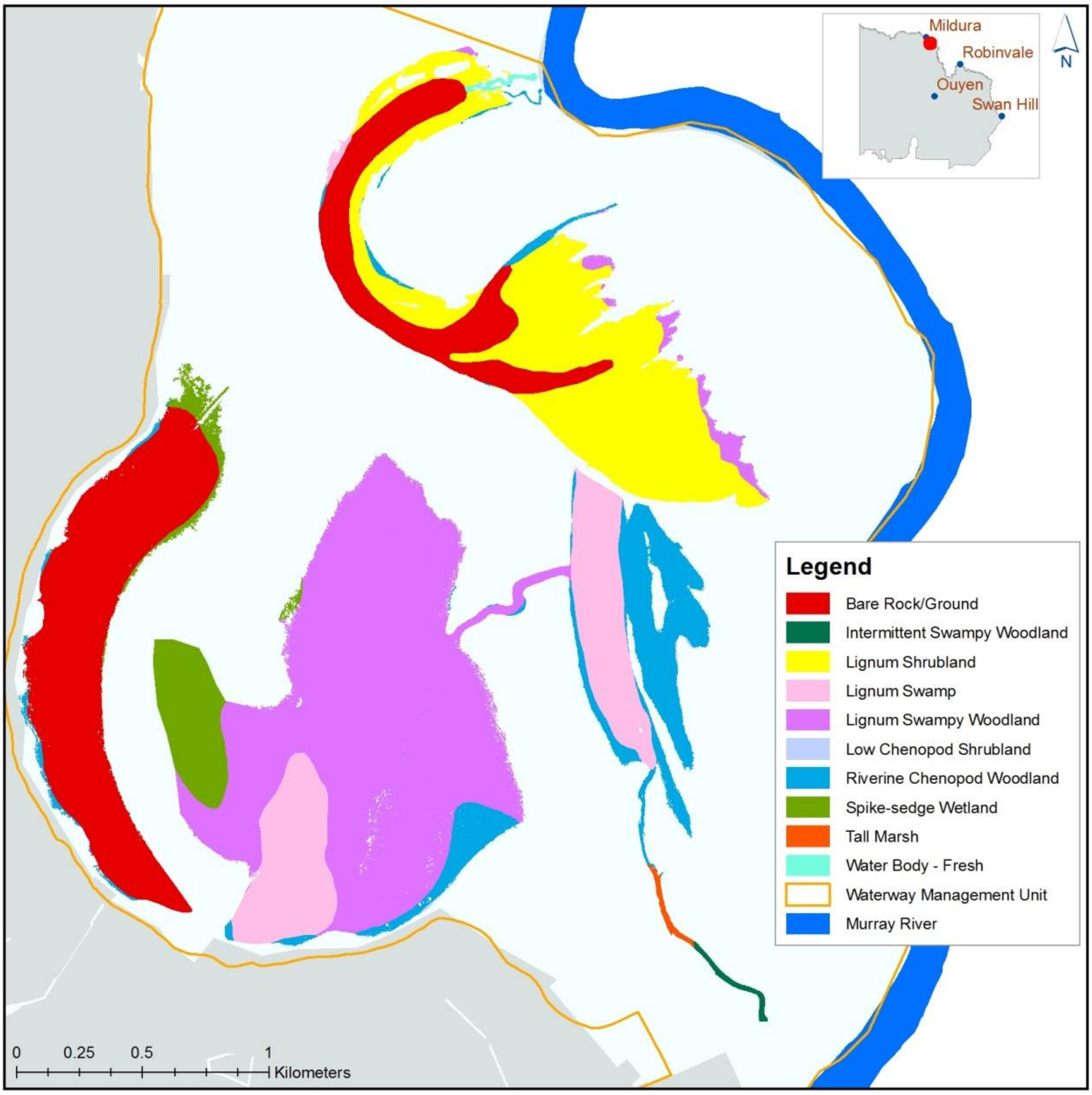


Figure 9 - EVCs within the target area of Psyche Woorlong

Lignum Shrubland occurs around the edges of Psyche Bend Lagoon at slightly higher elevations than the wetland bed. This EVC would experience a flooding frequency of one event every four to ten years under natural conditions, with a critical interval of 15 years between events (VEAC 2008). Ponding of two to four months is required to sustain plants, but continuous flooding is not tolerated.

A large area of Lignum Swampy Woodland occurs in the eastern lobe of Woorlong Wetland, along with a smaller area of Lignum Swamp. Lignum Swampy Woodland also supports stands of River Red Gum (*Eucalyptus camaldulensis*) and Black Box (*Eucalyptus largiflorens*). As at Psyche Bend Lagoon these EVC's are found at slightly higher elevations than the wetland bed. These EVC's would have experienced more frequent flooding under natural conditions of approximately one event every two to eight years. For these EVCs there is a critical interval of 15 years between flood events and ponding duration of two to six months. Lignum does not respond well to prolonged inundation.

For further detail of these and other the EVCs within the target area see Appendix 2.

Table 11 - Conservation status of water dependent EVCs in the target area

EVC No.	EVC Name	Bioregional Conservation Status Robinvale Plains Bioregion	Area (ha)
813	Intermittent Swampy Woodland	Depleted	0.98
808	Lignum Shrubland	Least Concern	67.77
104	Lignum Swamp	Vulnerable	40.32
823	Lignum Swampy Woodland	Depleted	128.73
102	Low Chenopod Shrubland	Depleted	0.18
103	Riverine Chenopod Woodland	Depleted	32.96
819	Spike-sedge Wetland	Vulnerable	18.04
821	Tall Marsh	Depleted	0.84
N/A	Water Body - Fresh	N/A	0.66
N/A	Bare Rock/Ground	N/A	86.62

Flora

Water dependent flora species listed in relevant Acts and agreements which have been recorded in the Kings Billabong Park are listed in Table 12. The water dependent EVCs in which the listed species are noted as being typical are also cross referenced; these are the EVCs which contain the Lignum communities. This gives an indication of the importance of maintaining these EVCs through an environmental water program to protect these listed species as well as the wide range of water dependent flora in the target area. A full list of flora recorded at the site can be found in Appendix 1.

Table 12 - Listed water dependent flora species recorded at the site

Common Name	Scientific Name	FFG status	DELWP status	EVC listing species
Jerry-jerry	Ammannia multiflora		V	
Small Water-fire	Bergia trimera		V	
Billabong Daisy	Brachyscome aff. gracilis (Kings Billabong)	L	V	
Hornwort	Ceratophyllum demersum		PK	
Native Couch	Cynodon dactylon var. pulchellus		PK	813
Lax Flat-sedge	Cyperus flaccidus		V	
Curly Flat-sedge	Cyperus rigidellus	L	EN	
Bearded Flat-sedge	Cyperus squarrosus		V	
Yelka	Cyperus victoriensis		PK	
Riverine Flax-lily	Dianella porracea		V	
Twin-flower Saltbush	Dissocarpus biflorus var. biflorus		R	
Pale Spike-sedge	Eleocharis pallens		PK	
Tall Nut-heads	Epaltes cunninghamii		V	
Cane Grass	Eragrostis australasica		V	808
Purple Love-grass	Eragrostis lacunaria		V	
Bristly Love-grass	Eragrostis setifolia		V	
Spreading Emu-bush	Eremophila divaricata subsp. divaricata		R	103
Spotted Emu-bush	Eremophila maculata var. maculata		R	
Summer Fringe-sedge	Fimbristylis aestivalis		PK	
Veiled Fringe-sedge	Fimbristylis velata		R	
Hydrilla	Hydrilla verticillata		R	
Inland Club-sedge	Isolepis australiensis		PK	
Warty Peppercress	Lepidium papillosum		PK	
Veined Peppercress	Lepidium phlebopetalum		EN	
Native Peppercress	Lepidium pseudohyssopifolium		PK	
Brown Beetle-grass	Leptochloa fusca subsp. fusca		R	
Button Rush	Lipocarpha microcephala		V	
Goat Head	Malacocera tricornis		R	
Bush Minuria	Minuria cunninghamii		R	
Smooth Minuria	Minuria integerrima		R	
Water Nymph	Najas tenuifolia		R	
Perfoliate Pondweed	Potamogeton perfoliatus s.l.		PK	
Long Tails	Ptilotus polystachyus var. polystachyus		EN	
Pin Sida	Sida fibulifera		V	

Common Name	Scientific Name	FFG status	DELWP status	EVC listing species
Legend **EPBC status: EXtinct, CRitically endangered, ENdangered, VUlnerable, Conservation Dependent, Not Listed** **FFG status: Listed as threatened, Nominated, Delisted, Never Listed, Ineligible for listing** **DELWP status: presumed EXtinct, Regionally Extinct, Extinct in the Wild, CRitically endangered, ENdangered, Vulnerable, Rare, Near Threatened, Data Deficient, Poorly Known, Not Listed**				

Lignum is considered to be the most significant floodplain shrub in mainland Australia due to its extensive distribution, local dominance and value as habitat (Roberts & Marston 2011). It has particular ecological value as waterbird breeding habitat (Rogers & Ralph 2011). Wetland birds that breed over water, such as Egrets, use flooded Lignum shrublands for resting and Blue-billed and Freckled Ducks nest on Lignum. Considering the large area of Lignum dominated EVC's within the target area (Table 11) the potential for appropriate environmental watering to restore valuable habitat is high.

Floating, emergent and submerged aquatic macrophytes species are present at Psyche Bend Lagoon and are important to the ecosystem, for example the submerged, salt tolerant Ruppia These plants are rooted to the wetland floor with their canopies floating on top of, very near, or well below the water surface. They rise and fall with water levels and provide a physical structure to the aquatic environment as well as providing a food source for waterbirds and habitat for fish including the Murray Hardyhead (Ecological Associates 2007b). Aquatic macrophytes are highly productive wetland habitats also providing shelter for macro-invertebrates and dabbling ducks such as the Freckled Duck that graze on this vegetation and the macro-invertebrates within it (Ecological Associates 2007b). Aquatic macrophytes are dependent on water for growth and reproduction, and under sudden draw down these plants lose support and collapse and die quickly. The ideal flood requirement is 9-12 months (Rogers & Ralph 2011). They may persist in wetlands that are frequently flooded but if summer drying occurs they will die off and be replaced by lake bed herbs (Ecological Associates 2007b).

Ellis (2013, pers. comm. 11th Dec) suggests that a gradual drawdown in water level may be required for Ruppia re-establishment and found the abundance of zooplankton increased in wetlands which underwent drawdown phases. Brock (1981) states that the drying of seeds and substrate during a drawdown is likely to break seed coating and make seeds more permeable to water on rewetting of the wetland.

5.2 Wetland depletion and rarity

Victoria's wetlands are currently mapped and are contained within a state wetland database, using an accepted state-wide wetland classification system, developed by Andrew Corrick from the Arthur Rylah Institute. Mapping was undertaken from 1981 using 1:25,000 colour aerial photographs, along with field checking. This database is commonly known as the 1994 wetland layer.

During this mapping, an attempt was made to categorise and map wetland areas occupied prior to European settlement. This was largely interpretive work and uses only the primary category, based on water regime. This is known as the 1788 layer. It has therefore been possible to estimate the depletion of wetland types across the state using the primary category only, based on a comparison of wetland extent between the 1788 and 1994 wetland layers.

Psyche Woorlong contains seven wetlands, five of which are in the target area. These wetlands have been classified using the Corrick-Norman wetland classification system as Permanent Open Freshwater and Semi-permanent Saline. There has been very little decrease in these wetland types in the Robinvale Plains Bioregion. Semi-permanent saline wetlands are now the most common type of wetland in the Mallee CMA region. These wetlands have increased in number and area since European settlement due to river regulation, clearing of native vegetation and the use of low-lying areas for saline irrigation drainage (MCMA 2006).

A summary of the Corrick classification of the wetlands and Psyche Woorlong, and the change in their distribution at multiple spatial scales is provided below in Table 13.

Table 13 - Changes in area of wetland types found in the target area by Corrick classification

Category	No of Wetlands in target area	Total area (ha)	Decrease in wetland area from 1788 to 1994		
			% Change in area in Victoria	% Change in area in Mallee CMA	% Change in Robinvale Plains Bioregion
Permanent Open Freshwater	1	64.4	-6	5	-1
Semi-permanent Saline	4	39.06	-7	9	100

Source: DELWP Biodiversity interactive maps, Mallee Wetland Strategy 2006

5.3 Ecosystem functions

Wetland ecosystems support distinctive communities of plants and animals and provide numerous ecosystem services to the community (DSE 2005). Floodplain wetlands perform important functions necessary to maintain the hydrological, physical and ecological health of river systems. These ecosystem functions include:

- enhancing water quality through filtering sediments and re-using nutrients;
- absorbing and releasing floodwaters;
- providing organic material to rivers to maintain riverine food chains; and
- providing feeding, breeding and drought refuge sites for an array of flora and fauna, especially waterbirds and fish.

Altered water regimes in the target area due to river regulation and dry conditions have seen a decrease in the frequency of inundation in these floodplain wetlands and therefore a decrease in the ability for these wetlands to perform these valuable ecosystem functions.

5.5 Social values

Cultural values

The Mallee has been occupied for thousands of generations by Indigenous people with human activity dated as far back as 23,400 years ago. The region's rich and diverse Indigenous heritage has been formed through the historical and spiritual significance of sites associated with this habitation; together with the strong connection traditional owners continue to have with the Mallee's natural landscapes.

Given the semi-arid climate of the region, ready access to more permanent water has been a major determinant of human habitation, and as such the highest density of identified Indigenous Cultural Heritage sites are located around or close to areas of freshwater sources.

Within the Mallee CMA region, the Murray River and its associated waterways were important habitation areas for multiple Aboriginal groups, containing many places of spiritual significance. The high number of Indigenous Cultural Heritage sites throughout the Murray floodplain is unique in Victoria, for both concentration and diversity. They include large numbers of burial, middens and hunting sites.

Waterways also play a large role in the region's more recent non-Indigenous heritage due to the historical infrastructure (e.g. buildings, irrigation and river navigation structures) they often contain. These places provide links to early industries and settlements and play a key part in the region's identity.

Cultural heritage

Kings Billabong Park is an important cultural site for the local indigenous people and the area was traditionally occupied by the Nyeri Nyeri and Latji Latji people. Earth features, shell deposits, scar trees and burial sites have been documented and records are held by Aboriginal Affairs Victoria (Parks Vic 2008). As is the case for most of the Murray River floodplain and beyond, it is recognised that waterways and floodplains are highly significant for the indigenous culture but the true extent of the number and types of sites present is still unknown. A contingency plan (Appendix 3) is in place should any further evidence of cultural heritage sites be discovered during site visits or works.

European heritage reflects the pioneering history of the area. Early development of irrigation in the Mildura region is evident in the remains of infrastructure such as the Red Cliffs main pumping station. Old concrete and timber marks the site where a punt, a small flat-bottomed boat, was used for transport across the river. The remains of houses are evident along the inlet to Kings Billabong. The Victorian Heritage Register lists Psyche Bend Pumps as an intact example of a steam irrigation pumping station (AHC 200) and they are protected by a Heritage Overlay under the Mildura Planning Scheme (Parks Vic 2008).

Recreation

The Kings Billabong Park is close to Mildura and is popular for swimming, camping, fishing, boating, four-wheel driving, picnics, barbeques, trail bike riding, horse riding and walking and these uses will continue in the park. The Park is also popular for bird watching with a bird hide overlooking Kings Billabong.

5.7 Economic values

The Park was logged until the 1950s to supply fuel for steam-powered paddleboats and pumps. There was also cattle grazing, cultivation and dried fruit rack sites in the reserve until 1989 (Parks Victoria 2013). The storage and transfer of irrigation water and tourism, including commercial houseboat moorings in the marina in the north of the park, are the economic interests which remain.

Psyche Woorlong continues to be or important economic value to the local irrigation district as an irrigation drainage disposal site.

5.8 Significance

The environmental, social and economic values outlined indicate the significance of this site. While these values do not constitute Psyche Woorlong being a unique or pristine site, the riparian and floodplain communities of the Murray River are important to the functioning of the river system and its sustainability. The Kings Billabong Park area is rich in biodiversity and has been recognised as the highest value conservation reserve in the Sunraysia area (SKM 2002). The Park provides essential habitat to native species and a refuge for listed flora and fauna species. The wetlands within the target area are also listed as Nationally Significant. The social and cultural values are important to local communities of the area. The values contained at Psyche Woorlong and specifically the target area for this plan makes this area a priority for protection and enhancement through environmental water management.

6 Ecological condition and threats

6.1 Current condition

One method for assessing the current condition of a wetland is the Index of Wetland Condition (IWC). The IWC defines wetland condition as the state of the biological, physical, and chemical components of the wetland ecosystem and their interactions. The condition of Woorlong Wetland was assessed in December 2009.

The IWC has five sub-indices based on the catchment of the wetland and its fundamental characteristics: physical form, hydrology, water properties, soils and biota. Each sub-index is given a score between 0 and 20 based on the assessment of a number of measures. The overall IWC score is not a simple summation of the sub index scores. A formula is used that weights each sub index according to the contribution it makes to the overall condition of the wetland. The wetland hydrology sub index for example contributes more to the overall score than the soils sub index.

The overall IWC score for Woorlong Wetland assessed in December 2009 was 6 out of 10, which is considered to be moderate (Table 14).

Table 14 - IWC sub index and overall scores for Woorlong Wetland

Wetland Name	Wetland Catchment	Physical Form	Hydrology	Water Properties	Soils	Biota (Vegetation)	Overall IWC Category
Woorlong Wetland (Basin 12)	Moderate	Excellent	Moderate	Moderate	Excellent	Very Poor	Moderate

Although the Woorlong Wetland scored moderate to excellent for most sub-indexes, the effects of salinity on the wetland and floodplain landscape are best reflected in the biota (vegetation) sub-index score of 'very poor' (Figure 10). The altered water regime is considered the major threat for the target area and is the primary factor behind the development of this EWMP.

Figure 10 - Psyche Bend Lagoon showing extensive salt and the algae species *Dunaliella salina*

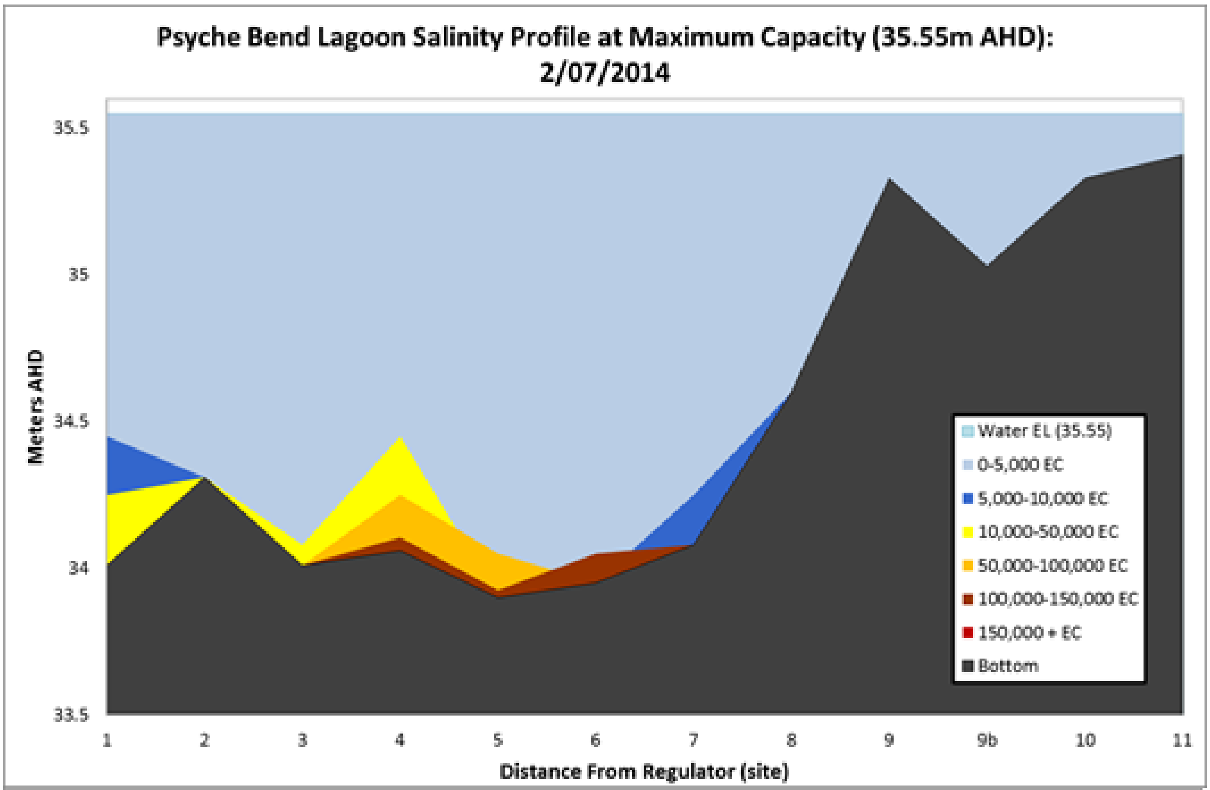
Salinity and water quality

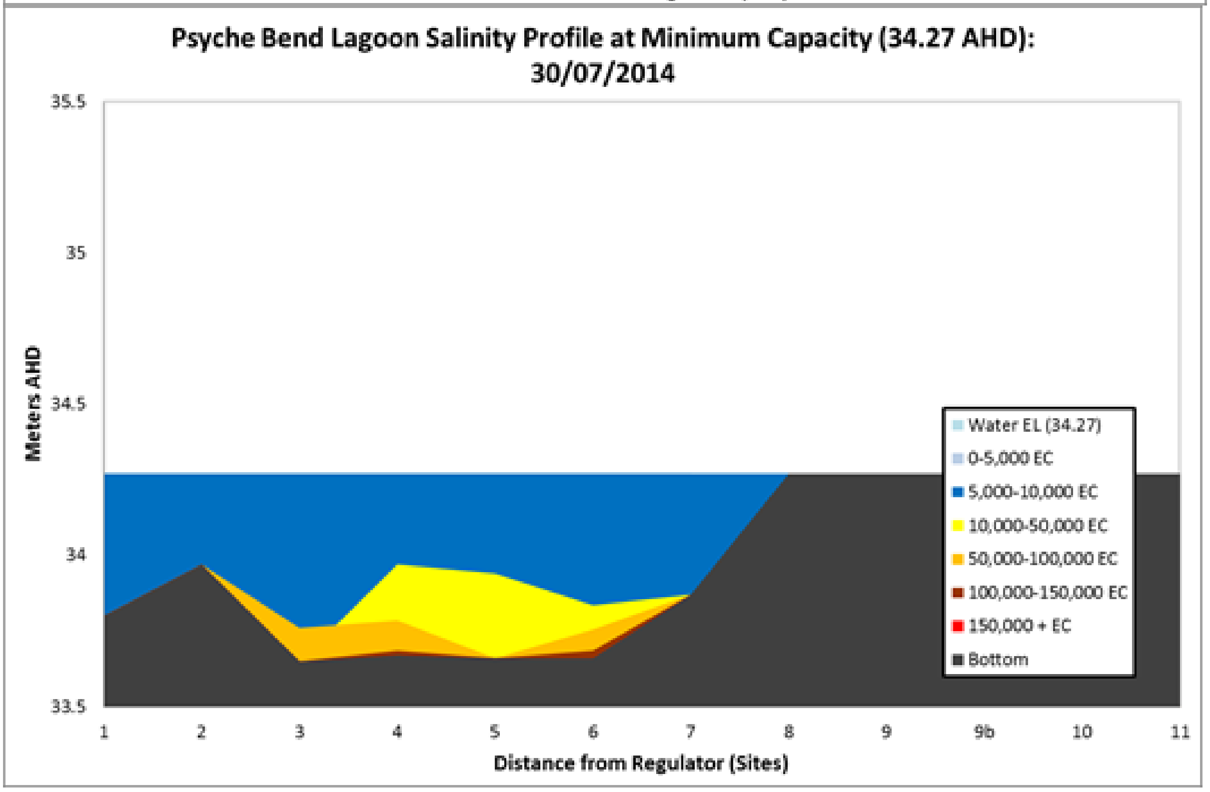
Psyche Bend Lagoon is an important component in the region's salinity management strategy and has been equipped with several monitoring sites including gauging boards for water elevation and telemetry monitors for measuring electrical conductivity and salinity data to support salinity accounting (Figure 11 and Figure 12).

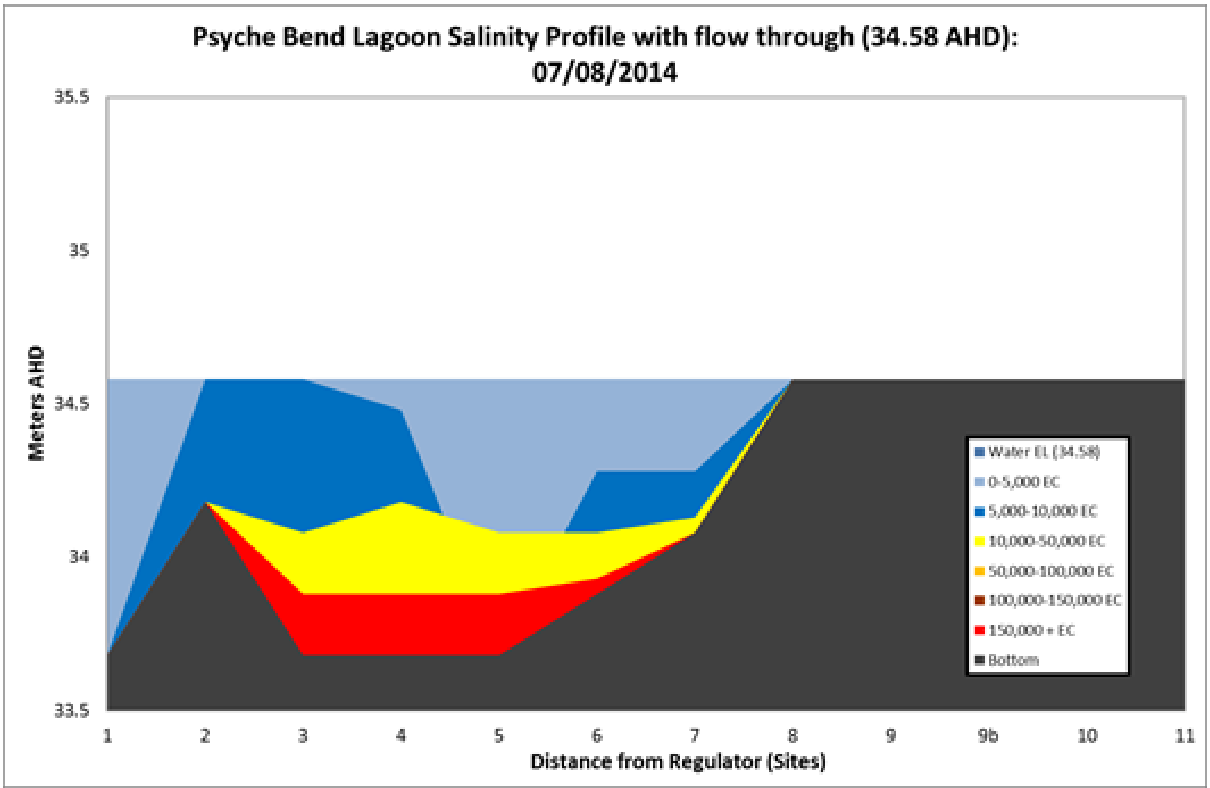
Figure 11 - Telemetry monitor at Psyche Bend Lagoon

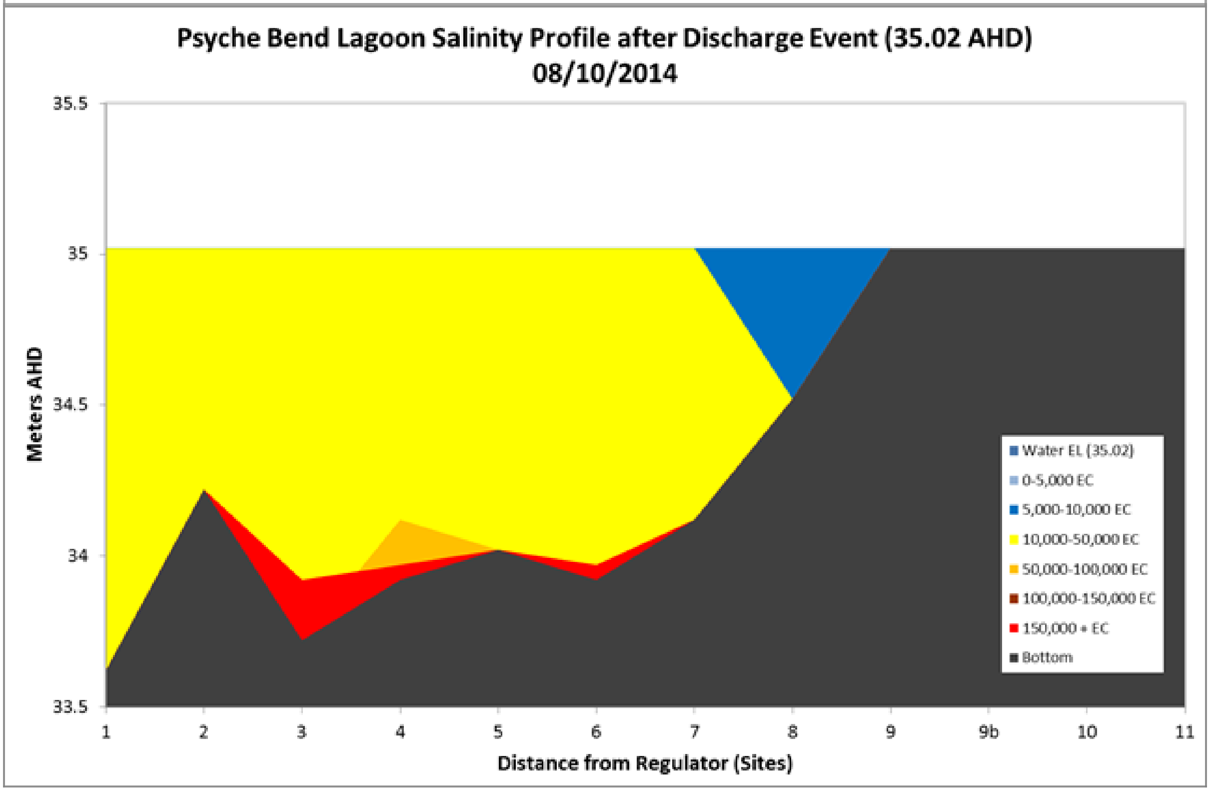
Water quality data collected by the Mallee CMA has indicated that Psyche Bend Lagoon is subject to stratification of the water column, meaning that denser saltier water sits at the bottom due to hydrostatic pressure, and fresher water sits on top. Figure 13 demonstrates the presence of stratification at Psyche Bend Lagoon showing that salinities of 100,000 - 150,000 EC exist in the bottom water layer throughout an environmental watering/flushing event. One month following the event, evidence of stratification remains. The risk of highly saline conditions, beyond the tolerances of Murray Hardyhead at the bottom of the water column in Psyche Bend Lagoon mean that translocation of the Murray Hardyhead is not feasible at this stage. Wetlands with salinity levels ranging from 1000 to 110,000 EC have been predominantly recorded as containing Murray Hardyhead, however it is not known whether the higher salinity levels would support all stages of the Murray Hardyhead lifecycle (MDFRC 2014). Regular flushing and freshening of the wetland is required to mix the stratified water column to allow successful translocation.

Figure 12 - Psyche Bend Lagoon aerial photo showing water quality survey site locations


Psyche Bend Lagoon Salinity Profile at Maximum Capacity (35.55m AHD): 2/07/2014
Meters AHD
35.5
35
34.5
34
33.5
1
2
3
4
5
6
7
8
9
9b
10
11
Distance From Regulator (site)
Water EL (35.55)
0-5,000 EC
5,000-10,000 EC
10,000-50,000 EC
50,000-100,000 EC
100,000-150,000 EC
150,000 + EC
Bottom


Psyche Bend Lagoon Salinity Profile at Minimum Capacity (34.27 AHD): 30/07/2014
Meters AHD
35.5
35
34.5
34
33.5
1
2
3
4
5
6
7
8
9
9b
10
11
Distance from Regulator (Sites)
Water EL (34.27)
0-5,000 EC
5,000-10,000 EC
10,000-50,000 EC
50,000-100,000 EC
100,000-150,000 EC
150,000 + EC
Bottom


Psyche Bend Lagoon Salinity Profile with flow through (34.58 AHD): 07/08/2014
Meters AHD
35.5
35
34.5
34
33.5
1
2
3
4
5
6
7
8
9
9b
10
11
Distance from Regulator (Sites)
Water EL (34.58)
0-5,000 EC
5,000-10,000 EC
10,000-50,000 EC
50,000-100,000 EC
100,000-150,000 EC
150,000 + EC
Bottom


Psyche Bend Lagoon Salinity Profile after Discharge Event (35.02 AHD) 08/10/2014
Meters AHD
35.5
35
34.5
34
33.5
1
2
3
4
5
6
7
8
9
9b
10
11
Distance from Regulator (Sites)
Water EL (35.02)
0-5,000 EC
5,000-10,000 EC
10,000-50,000 EC
50,000-100,000 EC
100,000-150,000 EC
150,000 + EC
Bottom

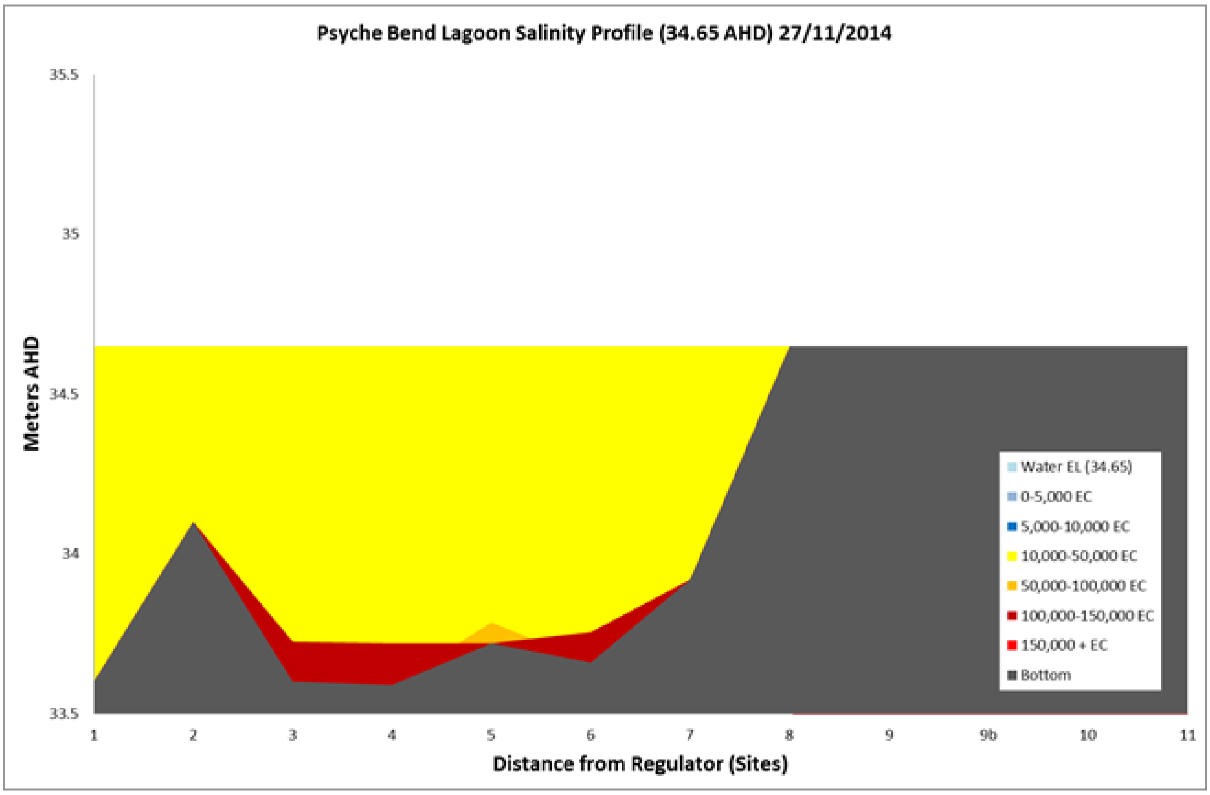


Figure 13 - Salinity long sections within the Psyche Bend Lagoon during and post an environmental watering/flushing event undertaken in 2014.

Vegetation condition

Red Gum woodlands are located adjacent to the Murray River and floodplain runners. Bluml (1992, cited in Ecological Associates 2007b) found extensive Black Box woodlands throughout the floodplain, which are degraded around Woorlong Wetland. Psyche Bend Lagoon and approximately 110 ha of surrounding vegetation has been severely degraded by saline drainage and ground water (Figure 14). To the south of the target area the vegetation is less affected with Black Box and Lignum and chenopod understory in good condition. Some low-lying swales and deep creek beds are severely salt affected, only supporting extremely salt tolerant species such as *Samphire* spp*.* and Noon-flower (*Disphyma crassifolium*) (Ecological Associates 2007b).The margin of Woorlong Wetland is covered by extensive reed beds of Cumbungi (*Typha spp.)* and Rushes (*Juncus spp*.) (Figure 15). Ecological associates found that reed beds cover 60 per cent of the vegetation component of Woorlong wetland.

Figure 14 - Psyche Bend Lagoon showing the salinised perimeter (photo from Ecological Associates 2016)

Figure 15 - Woorlong wetland extensive stands of Cumbungi (photo from Ecological Associates 2016)

6.2 Condition trajectory

Without management intervention in the form of environmental watering condition within the target area is expected to further decline. Dry conditions and salinity will continue to impact already severely stressed vegetation. This will result in loss of valuable habitat for listed fauna within the target area. Wetland productivity and biodiversity, which is directly dependent on water, will continue to decline.

The floodplain will continue to become drier and saltier resulting in reduced productivity, less carbon flux, and reduced functioning. Due to river regulation, flooding alone may not be enough to sustain floodplain vegetation communities as events of necessary magnitude to reach these wetlands have reduced in frequency and duration (Ecological Associates 2007b). Previous studies and watering events have provided evidence that the application of environmental water to the wetlands will improve conditions and provide habitat for a range of waterbirds.

Figure 16 - Psyche Bend Lagoon after environmental watering (2014)

6.3 Water related threats

Some of the threats which may have an impact at Psyche Woorlong include:

- Changed water regime
- Loss or reduction of wetland connectivity
- Poor water quality
- Invasive flora and fauna

Changed water regime

The regulation of the Murray River has seen the water regime through the Psyche Woorlong Wetland section altered. Flow events of the magnitude required to allow flows into the creeks and wetlands of the floodplain are less frequent and of shorter duration. This combined with dry conditions over the Millennium drought affects the vigour of the vegetation and places trees under stress, affecting the productivity and functioning of the floodplain ecosystem.

Permanent inundation of wetlands alters the hydrology and reduces water circulation. This can impact water temperature, dissolved oxygen, salinity and pH levels. Nutrient outflow can be reduced resulting in a build-up of salinity and/or pollutants. Sedimentation within the wetlands can lead to smothering of key habitat features. Biodiversity can decline as breeding cues and recruitment of flora and fauna are lost.

Poor water quality

The use of Psyche Bend Lagoon and Woorlong Wetland as an irrigation drainage basin has led to issues with salinity and resulted in degradation of the floodplain and its vegetation. At Woorlong Wetland Black Box woodland health has diminished and extensive succession of species such as Cumbungi and Spiny-rush has resulted on the wetland edge (Ecological Associates 2007b). Psyche Bend Lagoon and approximately 110ha of surrounding floodplain vegetation has been severely degraded by saline drainage and ground water (Ecological Associates 2007b).

Although increased salinity can be detrimental to surrounding vegetation, levels in Psyche Bend Lagoon and Woorlong Wetland may need to be maintained appropriately for translocation of Murray Hardyhead to these sites in the future. Murray Hardyhead tolerates moderately saline conditions, although lower levels may be required to facilitate breeding and recruitment (Backhouse et al. 2008).

Woorlong Wetland also receives stormwater from the Red Cliffs township. Stormwater run-off has the potential to transfer pollutants such as sediments, nutrients and chemicals from surrounding farmland into wetlands and waterways, which can result in algal blooms. Stormwater can also cause erosion and reduce local and downstream water quality (MCMA 2006).

Invasive species

Introduced fauna such as Common Carp pose a serious threat to the ecology of Psyche Woorlong wetlands. Carp have been found to contribute to the loss of aquatic vegetation and increased turbidity, resulting in loss of habitat for waterfowl (Purdy & Loyn 2008). This species also competes with the native fish for habitat and food as well as having a detrimental effect on water quality (MCMA 2003). This is of particular concern given that these wetlands are a proposed site for translocation of Murray Hardyhead. However, managing salinity levels for Hardyhead through controlled wetland drawdown and associated salinity increase can also help control Carp as they are less salt tolerant. Spencer and Wassen (2009, cited in Rogers & Ralph 2011, p.264) suggest that Common Carp also significantly reduce recruitment success of the Growling Grass Frog.

Agricultural and other weeds are an ongoing threat and management issue along the Murray River floodplain. At Woorlong Wetland dense stands of Cumbungi surround the wetland edge. This plant uses large amounts of water and can alter the wetland character, reduce plant diversity and obstruct water flow (Roberts & Marston 2011). Environmental water can be used to manage this species by maintaining ponding at high enough levels to submerge the dense Cumbungi stands for prolonged periods.

7 Management objectives

7.1 Management goal

The long term management goals for Psyche Woorlong are to:

- Maintain Woorlong wetland as an open drought tolerant wetland community dominated by chenopods and Lignum.
- Maintain Psyche Bend Lagoon as a permanent saline wetland supporting habitat for wading birds and possible translocation and self-sustaining population of Murray Hardyhead.

7.2 Ecological objectives

Ecological objectives represent the desired ecological outcomes of the site based on the key values outlined in Water Dependent Values section of this EWMP. In line with the Victorian Waterway Management Strategy (VWMS), the ecological objectives are expressed as the target condition or functionality for each key value.

The ecological objectives for Psyche Bend Lagoon are:

- Self-sustaining population of Murray Hardyhead following translocation
- Extensive beds of Ruppia spp. in wetland
- Provide shallow water habitat and exposure of mudflats to support foraging and resting of small waders
- Maintain high levels of aquatic productivity

The ecological objectives for Woorlong Wetland are:

- Healthy and productive Lignum and chenopod communities
- Provide seasonal aquatic that supports a diverse range of small fish and frogs
- Provide shallow water habitat and exposure of mudflats to support foraging and resting of small waders
- Reduce the area of Woorlong wetland dominated by reed (Phragmites and Cumbungi) communities
- Maintain high levels of aquatic productivity

Justification for the ecological objectives is provided in Table 15.

As more is learnt about Psyche Woorlong through monitoring its response to the watering events, the principles of adaptive management, along with availability of environmental water sources will guide future management actions at this site.

Table 15 – Justification of ecological objectives for the site

Ecological Objective	Justification (Value based	
Psyche Bend Lagoon		Water area
Self-sustaining population of Murray Hardyhead following translocation.	If suitable conditions are provided, Murray Hardyhead could be reintroduced to Psyche Bend Lagoon. Ongoing management of the salinity, water regime and wetland productivity would be required.	Psyche
Extensive beds of *Ruppia* spp. in wetland.	*Ruppia* spp. is particularly important for Murray Hardyhead; they need sufficient depth of water over Ruppia beds to allow successful spawning and recruitment in spring and summer.	Psyche
Provide shallow water habitat and exposure of mudflats to support foraging and resting of small waders.	The fringing areas of semi-permanent saline wetlands provide suitable resting and foraging habitat for these species.	Psyche and Woorlong
Healthy and productive Lignum and chenopod communities.	Inundation of Lignum woodlands will allow colonisation by small native fish including Gudgeon and Murray-Darling Rainbowfish. Shelter and feeding habitat for frogs will also expand from the fringing wetland areas to the refuge of the deeper wetland areas. Healthy Lignum can also provide shelter and feeding sites for Carpet Python and Woodland birds such as Brown Tree-creeper.	Woorlong
Provide seasonal aquatic that supports a diverse range of small fish and frogs.	Frogs and small native fish, such as Gudgeon, will visit Woorlong wetland when flooded and may breed. In turn, these fish will be an important food source for some birds.	Woorlong
Reduce the area of Woorlong wetland dominated by reed (Phragmites and Cumbungi) communities.	Managing cumbungi stands would improve water flow and allow other native flora species to flourish.	Woorlong
Maintain high levels of aquatic productivity	Alternating periods of inundation and exposure accelerate the decomposition of organic matter and increase availability for organic carbon and mineral nutrients in the wetland food web.	Psyche and Woorlong

7.4 Hydrological objectives

Hydrological objectives describe the components of the water regime required to achieve the ecological objectives for the target area. The hydrological requirements to achieve the objectives are presented in Table 16.

Evidence from the previous flushing events showed a correlation between the frequency of flushing and a reduction in salt loads. Effective removal of salt from the system should also increase the opportunity for the improvement of the vegetation surrounding the wetlands.

Black Box stands occur in the fringing areas and floodplain within the target area. They require flooding to occur every three to seven years with durations of two to six months. This species can tolerate shorter flood durations but plant vigour will suffer. Although timing of flood events is not crucial for Black Box it will affect understorey and other woodland biota. Black Box trees may survive prolonged periods of 12 to 16 years with no flooding but tree health will suffer and woodlands will become dysfunctional (Roberts and Marston 2011).

Lignum can tolerate a wide range of wet and dry conditions as well as moderate salinity levels. Flood requirements vary with frequencies of one to three years needed to maintain large shrubs with vigorous canopy and flooding every three to five years for maintenance of healthy shrubs. Intervals of seven to ten years can be tolerated by small shrubs but growth will decline and plants in this state do not accommodate nesting by birds. Durations of three to seven months sustain vigorous canopy, but continuous flooding is detrimental. Although timing of flooding is not crucial for Lignum, following natural seasonality is encouraged to provide for understorey and wetland plants (Roberts & Marston 2011).

If Psyche Bend Lagoon is to support Murray Hardyhead populations water will need to remain in the wetlands on a permanent basis. This will require long-term annual environmental water inflows to the wetland to maintain adequate levels to allow Murray Hardyhead to complete their life cycle and increase in abundance. It is estimated that the site will be suitable for the translocation of fish within 10 years. Salinity levels should also be maintained within a range which allows Murray Hardyhead to complete their life cycle. Environmental watering should commence from August to October to coincide with Hardyhead breeding season (October – November). Water levels should be high enough to inundate exposed sediments to promote a rise in zooplankton as a food source for breeding Murray Hardyhead. Water levels should be allowed to decrease through summer to expose wetland sediments and fringing vegetation whilst also maintaining *Ruppia spp*. beds within the wetlands.

Although continuous flooding may seem appropriate for aquatic macrophytes such as *Ruppia spp*., seasonal variation in water levels is also beneficial for these plants. Brock (1981) states that the drying of seeds and substrate during a dry phase in ephemeral wetlands habitats is likely to break the seed coating and make seeds more permeable to water on rewetting of the wetland. These aquatic species may persist in wetlands that are frequently flooded but if complete drying of the wetland occurs over summer they will die off and be replaced by lake bed herbs (Ecological Associates 2007b). Roberts & Marston (2011) states a slow drawdown of water level is required to prevent collapse of plants. Ellis (2013, pers. comm., 11th Dec) supports this, suggesting a gradual drawdown phase is essential for *Ruppia spp*. establishment. Drawdown of water level in the wetlands is proposed to occur naturally through evaporation.

The growth of Cumbungi and Common Reed can be controlled by providing a water regime that is unsuitable for the plants' growth. The most important factor to eliminate is reliable shallow flooding or waterlogging over summer. This can be achieved by providing flooding that is too deep. Growth will be reduced if depths of more than 1 m are sustained during the growing season. Growth will be largely suppressed if depths of 2 m are provided. Growth can also be suppressed by drying out wetlands during summer (Ecological Associates, 2016). If wetlands are flooded only in spring and not in summer, Cumbungi and Common Reed growth will be sparse and limited in extent (Ecological Associates, 2016). It can be difficult to completely dry out wetlands with a shallow water table, which can sustain growth over summer. Groundwater at Woorlong is close to the surface. Fresh groundwater on the western side of the wetland may continue to support growth of reeds, even during drying periods, although drying is likely to be more effective on the eastern side where groundwater is saline and reed growth will be supressed (Ecological Associates, 2016).

Table 16 - Hydrological objectives for Psyche Bend Lagoon and Woorlong Wetland target area

Ecological Objectives	Water management area	Mean frequency of events (No. per 10 years)			Tolerable interval between events		Duration of ponding			Preferred timing of inflows	Target supply level m AHD	Volume to fill to TSL (ML)
		Min	Opt	Max	Min	Max	Min	Opt	Max			
Self-sustaining population of Murray Hardyhead following translocation.	Psyche Bend Lagoon	10	10	10	0	0	12	12	12	Late Winter (Aug) to early Spring (Oct)	36	951
Extensive beds of Ruppia spp. in wetland.	Psyche Bend Lagoon	Permanent ponding with variation in water levels								N/A	35.5	
Healthy and productive Lignum and chenopod communities	Psyche Bend Lagoon, Woorlong Wetland and floodplain	3	5	10	2	7	3	5	7	Winter/Spring	36 – 37.5	1643
Improve aquatic macrophyte (submerged and emergent) diversity and area	Psyche Bend Lagoon, Woorlong Wetland and floodplain	Permanent ponding with variation in water levels								N/A	36 – 37.5	1643
Improve and maintain salinity levels to meet standards required for Murray Hardyhead and other key species (between 5,000 and 30,000 EC)	Psyche Bend Lagoon	3	5	20	1	1	N/A			N/A	N/A	N/A
Reduce the area of Woorlong wetland dominated by reed (Phragmites and Cumbungi) communities.	Woorlong Wetland	3	5	10	2	3	Drying event			Summer	-	-

Provide shallow water habitat and exposure of mudflats to support foraging and resting of small waders.	Psyche Bend Lagoon, Woorlong Wetland and floodplain fringe	Variability in water level	Permanent ponding with variable water level to alternately inundate/expose fringing vegetation and mud flats	Late winter/early spring	36-37.5	1643
Provide seasonal aquatic that supports a diverse range of small fish and frogs.	Woorlong Wetland	Achieved through other objectives				
Maintain high levels of aquatic productivity	Psyche Bend Lagoon, Woorlong Wetland and floodplain fringe	Variability in water level				

7.5 Watering regime

The wetland watering regime has been derived from the ecological and hydrological objectives. To allow for adaptive and integrated management, the watering regime is framed using the seasonally adaptive approach. This means that a watering regime is identified for optimal conditions, as well as the maximum and minimum tolerable watering scenarios. The minimum watering regime is likely to be provided in drought or dry years, the optimum watering regime in average conditions and the maximum watering regime in wet or flood years.

The optimal, minimum and maximum watering regimes for the short term goal of reducing salinity and the longer-term goals involving Murray Hardyhead introduction to Psyche Bend Lagoon are described below.

Woorlong wetland and floodplain

Inundate Woorlong wetland and floodplain to 37.5m AHD three years in every ten years. Allow water to recede naturally to expose the wetland bed. Ensure that local drainage water is diverted away from Woorlong wetland to ensure control of reeds.

The watering regime for Woorlong wetland is the optimal regime. A maximum regime has not been described, as further increased frequency and duration of watering would lead to an unacceptable salinity impact. A minimum watering regime has not been described as reduced watering frequency and duration would lead to unacceptable risk to the vegetation community and other aspects of the wetland and floodplain ecology.

Psyche Bend Lagoon

Minimum regime

Stage 1 – Short-term regime aimed at salinity management and establishment of diverse macrophyte community

Fill Psyche Bend Lagoon to 35m AHD every year in late winter; allow water to recede naturally through late summer/spring to a minimum level of 34.5m AHD.

Stage 2 – Subject to Murray Hardyhead reintroduction

Maintain Psyche Bend Lagoon as a permanent saline wetland, with seasonally variable water levels. Fill/top up Psyche Bend Lagoon annually in spring (August to October) to 36m AHD, allow water level to decrease through late summer/autumn to a minimum of 35m AHD exposing fringing vegetation and mudflats. Ensure that minimum water level will maintain inundation of Ruppia spp. beds.

Optimal regime

Stage 1 – Short-term regime aimed at salinity management and establishment of diverse macrophyte community

Fill Psyche Bend Lagoon to 36m AHD every year in late winter, allow water to recede naturally through late summer/spring to a minimum level of 35m AHD. Three years in ten open regulators to Murray River allowing release of water and a flush of salinity. Ensure that flush is undertaken in accordance with the operating rules for flushing events at Psyche Bend Lagoon.

Stage 2 – Subject to Murray Hardyhead reintroduction

Maintain Psyche Bend Lagoon as a permanent saline wetland, with seasonally variable water levels. Fill/top up Psyche Bend Lagoon annually in spring (August to October) to 36m AHD, allow water level to decrease through late summer/autumn to a minimum of 35m AHD exposing fringing vegetation and mudflats. Ensure that minimum water level will maintain inundation of Ruppia spp. beds.

Maximum regime

Stage 1 - Short-term regime aimed at salinity management and establishment of diverse macrophyte community

Fill Psyche Bend Lagoon to 36m AHD every year in late winter early, allow water to recede naturally through late summer/spring to a minimum level of 35m AHD. Twice in two consecutive years in ten years, open regulators to Murray River allowing release of water and a flush of salinity. Ensure that flush is undertaken in accordance with the operating rules for flushing events at Psyche Bend Lagoon.

Stage 2 – Subject to Murray Hardyhead reintroduction

As per stage 1.

8 Managing risks to achieve objectives

Mosquitoes are a concern of local residents at Woorlong Wetland. Although residents have expressed their desire for water to remain in the wetland over summer, they are aware that mosquitoes use still water bodies for reproduction. Mosquito populations are facilitated by aquatic vegetation, such as Cumbungi, which protect larvae from predators. However, where wetlands occur in open areas, like Woorlong Wetland, wind exposure can disturb larval respiration and minimize mosquito problems. Deep open water between vegetation also reduces mosquito occurrence (Russell 1999).

Residents were also concerned about the movement of snakes out of the wetland and surrounding Park once watering commences. It is likely that some movement of snakes will occur and it is difficult to predict whether this will impact local properties. Under natural flood events snakes will move away from the area of inundation, not only to avoid water, but to follow prey species which also disperse in response to flood (Madsen & Shine 1996). This movement may be unavoidable but actions can be taken to minimize the risk of snakes taking up residence in urban yards by keeping gardens tidy and removing piles of wood, clippings or other rubbish which snakes may use for shelter. Removing food sources such as rodents and discouraging frogs and birds may also help. Commencement of environmental watering in winter may help minimize the dispersal of snakes and establishment of mosquitoes.

Delivery Plans will be developed for all wetland sites allocated environmental water. A broad risk assessment has been undertaken for the system to identify any major risks which would require mitigation measures (Table 17). A more detailed risk assessment will be undertaken by the Mallee CMA in the development of the delivery plan taking into consideration the broad risk assessment. These plans are signed-off by the Victorian Environmental Water Holder before delivery commences.

Table 17 - Potential risks associated with environmental water delivery

Threat	Likelihood	Consequence	Risk – H, M, L (Likelihood x Consequence)	Management Measure	Residual Risk
Salinity Impact at Morgan is >0.1EC	Likely	Major - Accountable Action required	High	The salinity impact associated with environmental watering has been modelled and the environmental watering scenario for Psyche is an accountable action. Mallee CMA has set aside credits under the BSM 2030 plan to account for this action.	Medium

Threat	Likelihood	Consequence	Risk – H, M, L (Likelihood x Consequence)	Management Measure	Residual Risk
Flood duration too long or too short	Possible	Moderate - Water regime does not support breeding and feeding requirements of fauna or vegetation establishment and growth	Medium	Determination of water requirements to support potential breeding events through monitoring	Medium
Inability to provide optimal water regime to the target area	Possible	Moderate - Failure to achieve hydrological and ecological objectives for the site	Medium	Monitor flood duration to inform water delivery	Low
Reduced water quality in the wetlands	Possible	Major - Reduced habitat for aquatic vegetation and native fish	High	Monitor the ecological response of the wetlands to flooding	Medium
Flooding of surrounding private land	Unlikely	Moderate	Low	N/A	
Increased recruitment and dispersal or alien fish	Likely	Major - Decreased public support for future environmental watering actions	High	Monitor the response of the wetlands to flooding. Install a carp screen Implement an appropriate drying regime.	Medium
Growth and establishment of aquatic pest plants – particularly Cumbungi	Possible	Moderate - Reduced habitat quality and increased competition for native aquatic plant species	Medium	Watering regime in Woorlong has been developed to minimise Cumbungi growth	Low

9 Environmental water delivery infrastructure

9.1 Constraints

Woorlong wetland will be gradually filled to 37.5m AHD via the numerous irrigation drainage channels or through pumping. It will require approximately 346 ML of water.

With proposed infrastructure in place and the northern regulator at 904 river km closed, Psyche Bend Lagoon will be filled to 36m AHD via the water course connecting Psyche Bend Lagoon with the Murray River at 910 river kilometres, requiring >2700 ML. As with previous watering events; to allow flushing of Psyche Bend Lagoon the gates at the northern end at river km 904 connecting all three wetland to the Murray River will be opened.

Current infrastructure limits the extent of wetland area which can be inundated by environmental watering at Psyche Woorlong to 102 ha. Currently water begins to break through low points and return to the Murray River rather than being held on the floodplain at higher level. Infrastructure such as permanent levees and regulators would increase the extent of inundation to the whole target area and prevent this breakout. The proposed infrastructure would be operated for ecological benefits including lateral connectivity with the Murray River.

9.2 Irrigation modernisation

The Mallee CMA is working with Lower Murray Water who manages the irrigation infrastructure within the Kings Billabong Park to ensure that future irrigation modernisation will incorporate consideration of the environmental values of the Psyche Bend and Woorlong wetland areas.

9.3 Infrastructure recommendations

Ecological Associates (2007) concluded that the best environmental value for money spent at Psyche Woorlong would be achieved by operating the regulator at the main connection between Psyche Bend Lagoon and the River Murray to promote wetland conservation values. However, while this option may improve salinity levels in the wetland, the discharge of highly saline water into the Murray under this option is unacceptable under Basin Salinity Management Strategy protocols.

A second, more expensive, but more appropriate option suggested by Ecological Associates (2007) involves lowering sills and creating connections to Psyche Bend Lagoon from the south to enhance flooding opportunities.

Works to enable management of the billabongs at Psyche Woorlong are shown in Figure 17 and include:

- Road raising and box culverts installed to allow for high flows or pumped water to move across the floodplain and provide lateral connection to the river.
- Rehabilitation of levees and weirs to assist with water management.

The proposed works would significantly increase the volume of water able to be delivered and area of floodplain able to be inundated. Lateral connection to the river also allows movement of fish and water.

Funding for detailed designs for these infrastructure upgrades is currently being sought.

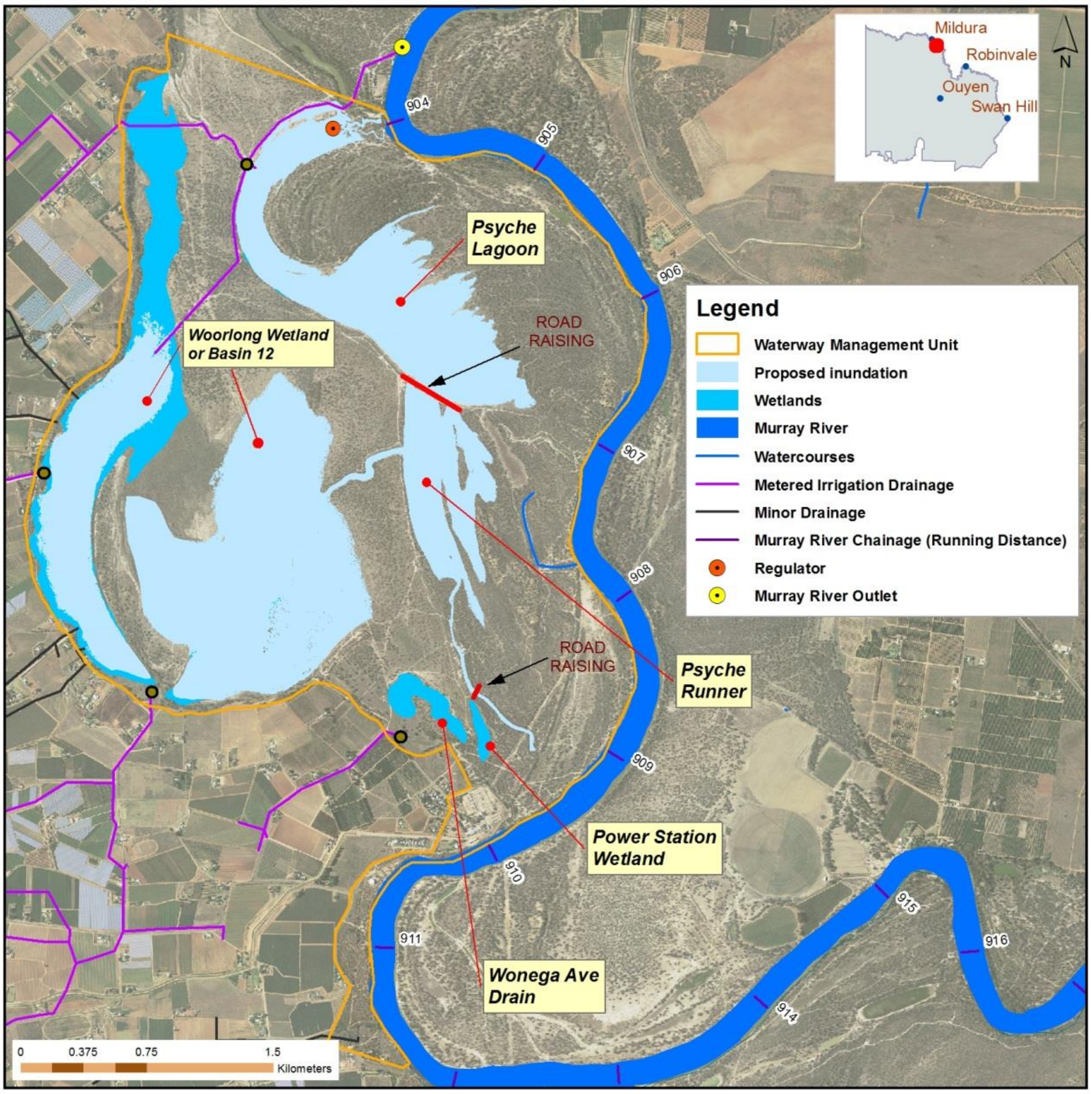


Figure 17 - Anticipated inundation extent of Psyche Woorlong target area with proposed infrastructure in place

10 Demonstrating outcomes

10.1 Monitoring priorities at the site

Ecological monitoring is required to demonstrate the effectiveness of environmental watering in achieving ecological objectives, to help manage environmental risks and to identify opportunities to improve the efficiency and effectiveness of the program. The following monitoring is recommended:

- Monitoring of water quality condition on a regular basis, including monitoring of salinity levels through the water column to identify seasonality of stratification. Water quality monitoring would occur throughout the year, and would intensify during watering events.
- Monitoring of groundwater bores to identify salinity and water table levels, and to confirm that watering will abate the leaching of highly saline groundwater through the Parilla Sands aquifer into the wetlands.
- Monitoring of water quality in release water.
- Photo point monitoring will be conducted before and after watering events to measure the success of environmental water in improving wetland and riparian vegetation communities;
- Other incidental observations that may occur in the course of the monitoring methods above, such as visitation by waterbirds and other species to the wetlands during and after watering events.
- Monitoring of aquatic macrophytes, to determine extent of Ruppia and other key structural habitat species likely to support Murray Hardyhead (following translocation).
- Monitoring of reed extent.
- Index of Wetland Condition assessments should be undertaken every 5 years at the site to monitor the health of the vegetation communities in response to the implementation of the EWMP.

Detailed monitoring of environmental water delivery would be dependent on funding from the State or Commonwealth governments.

11 Consultation

This Plan was developed in collaboration with key stakeholders namely Parks Victoria, DELWP, local interest groups, and nearby residents (Table 18).

Those involved in the consultation phase were very interested in seeing the health of the wetlands and surrounding floodplain improved through environmental watering events. Residents that live in close proximity to Woorlong Wetland were concerned with issues surrounding a lack of water in the wetland over the summer period causing a noxious odour and reduced recreational opportunities at the wetland and surrounding parkland.

Table 18 - Consultation Process for development of Psyche Woorlong Environmental Water Management Plan

Meeting date	Stakeholders	Details
Ongoing	Parks Victoria	Consultation on environmental management and project development
21st November 2013	Community Reference Group	Presentation of draft plan and request for input/feedback
21st November 2013	Friends of Kings Billabong	Presentation of draft plan and request for input/feedback
21st November 2013	Local residents/community	Presentation of draft plan and request for input/feedback
24th October 2013	Mallee CMA River and Wetlands Technical Advisory Committee	Presentation on development of EWMP
2014 – 2015	Local Residents/Community	Ongoing consultation on environmental watering program
2014	Lower Murray Water	Ongoing consultation on environmental watering program
Feb 2015	Mallee CMA – Land and Water Advisory Group (Waterway Health Specialists)	Discuss ecological objectives and proposed environmental watering actions
March 2015	Aboriginal Reference Group	Discuss proposed environmental watering actions and direct engagement strategies with Traditional Owners.

12 Knowledge gaps and recommendations

This plan is based on best information at the time of writing. The information sources used in the development of this report have a number of limitations. These limitations include that the data contained in the Flora Information System and the Atlas of Victorian Wildlife comes from a combination of incidental records and systematic surveys. The data varies in accuracy and reliability due to the distribution and intensity of survey efforts. In addition, the lack of knowledge about the distribution and characteristics of invertebrates and non-vascular plant species means the data is weighted towards the less cryptic elements of flora and fauna, i.e. vascular flora and vertebrates. This report also draws on material collated from management plans, research documents and published literature. These sources vary in their age and hence the degree to which they reflect the current situation. However, the Plan is intended to be a live document and will be amended as new information becomes available.

Some areas where further knowledge would be beneficial are outlined in Table 19.

A cultural heritage management plan and salinity impact assessment would be essential before any on ground works could be undertaken.

Table 19 - Knowledge gaps and recommendations for the target area

Knowledge gaps and data	Action recommended	Responsibility
Conceptual and detail designs for the management of infrastructure works	Engage consultants to carry out investigations and report	MCMA / LMW
Accurate depth and volumes for the wetland	Install depth gauges and bathymetric survey	MCMA
Flora and fauna surveys	Data collection and monitoring	MCMA
Impacts of climate variability	Data collection and monitoring	MCMA
Assessment of salinity impacts on the Murray River under proposed watering regimes	Engage consultants to carry out investigations and report	MCMA
Further assessment of Psyche Bend Lagoon for the re-introduction of Murray Hardyhead	Continue water monitoring	MCMA
Continue to build understanding of the optimal salinity conditions for Psyche Bend Lagoon and Woorlong Wetland, including the long term interactions with groundwater, irrigation and drainage.	Ongoing investigation of surface water groundwater and irrigation water interaction	MCMA

*Implementation of any of the above recommendation would be dependent on investment from Victorian and Australian Government funding sources as projects managed through the Mallee CMA

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14 Abbreviations and acronyms

ANCA	Australian Nature Conservation Agency
CAMBA	China-Australia Migratory Bird Agreement
DELWP	Department of Environment, Land, Water and Planning
DNRE	Department of Natural Resources and Environment
DSE	Department of Sustainability and Environment
EPBC	*Environment Protection and Biodiversity Conservation Act 1999*
EVC	Ecological Vegetation Class
EWMP	Environmental Water Management Plan
EWH	Environmental Water Holder
EWR	Environmental Water Reserve
FFG	Flora Fauna Guarantee Act
FSL	Full Supply Level
JAMBA	Japan-Australia Migratory Bird Agreement
MCMA	Mallee Catchment Management Authority
MDBA	Murray-Darling Basin Authority (formally Murray-Darling Basin Commission, MDBC)
TSL	Targeted Supply Level
VEAC	Victorian Environmental Assessment Council
VEWH	Victorian Environmental Water Holder
VWMS	Victorian Waterway Management Strategy
WMU	Waterway Management Unit

Appendix 1. Flora and fauna species list

Flora – Native

Common Name	Scientific Name	Records
Small Cooba	*Acacia ligulata*	1
Mallee Wattle	*Acacia montana*	1
Spine Bush	*Acacia nyssophylla*	3
Umbrella Wattle	*Acacia oswaldii*	1
Willow Wattle	*Acacia salicina*	1
Eumong	*Acacia stenophylla*	8
Cattle Bush	*Alectryon oleifolius subsp. canescens*	4
Buloke	*Allocasuarina luehmannii*	1
Lesser Joyweed	*Alternanthera denticulata s.l.*	3
Lesser Joyweed	*Alternanthera denticulata s.s.*	2
Jerry-jerry	*Ammannia multiflora*	1
Box Mistletoe	*Amyema miquelii*	2
Nodding Chocolate-lily	*Arthropodium fimbriatum*	1
Common Woodruff	*Asperula conferta*	2
Small Saltbush	*Atriplex eardleyae*	2
Slender-fruit Saltbush	*Atriplex leptocarpa*	5
Spreading Saltbush	*Atriplex limbata*	1
Flat-top Saltbush	*Atriplex lindleyi*	13
Corky Saltbush	*Atriplex lindleyi subsp. inflata*	3
Old-man Saltbush	*Atriplex nummularia*	1
Dwarf Old-man Saltbush	*Atriplex nummularia subsp. omissa*	1
Coral Saltbush	*Atriplex papillata*	6
Mat Saltbush	*Atriplex pumilio*	1
Silver Saltbush	*Atriplex rhagodioides*	1
Berry Saltbush	*Atriplex semibaccata*	7
Spiny-fruit Saltbush	*Atriplex spinibractea*	4
Saltbush	*Atriplex spp.*	1
Sprawling Saltbush	*Atriplex suberecta*	8
Common Wallaby-grass	*Austrodanthonia caespitosa*	1
Bristly Wallaby-grass	*Austrodanthonia setacea*	3

Graceful Spear-grass	*Austrostipa acrociliata*	1
Plump Spear-grass	*Austrostipa aristiglumis*	1
Balcarra Spear-Grass	*Austrostipa nitida*	1
Knotty Spear-grass	*Austrostipa nodosa*	2
Rough Spear-grass	*Austrostipa scabra subsp. falcata*	2
Spear Grass	*Austrostipa spp.*	1
Pacific Azolla	*Azolla filiculoides*	2
Ferny Azolla	*Azolla pinnata*	1
Small Water-fire	*Bergia trimera*	1
Marsh Club-sedge	*Bolboschoenus medianus*	4
Billabong Daisy	*Brachyscome aff. gracilis (Kings Billabong)*	4
Woodland Swamp-daisy	*Brachyscome basaltica var. gracilis*	1
Variable Daisy	*Brachyscome ciliaris*	3
Variable Daisy	*Brachyscome ciliaris var. lanuginosa*	1
Lobe-seed Daisy	*Brachyscome dentata*	4
Hard-head Daisy	*Brachyscome lineariloba*	16
Leek Lily	*Bulbine semibarbata*	1
Small Purslane	*Calandrinia eremaea*	7
Slender Cypress-pine	*Callitris gracilis subsp. murrayensis*	2
Pale Beauty-heads	*Calocephalus sonderi*	11
Blue Burr-daisy	*Calotis cuneifolia*	4
Hairy Burr-daisy	*Calotis hispidula*	11
Yellow Burr-daisy	*Calotis lappulacea*	1
Rough Burr-daisy	*Calotis scabiosifolia*	1
Tufted Burr-daisy	*Calotis scapigera*	1
Plains Sedge	*Carex bichenoviana*	3
Spiked Centaury	*Centaurium spicatum*	1
Hornwort	*Ceratophyllum demersum*	1
Flat Spurge	*Chamaesyce drummondii*	3
Crested Goosefoot	*Chenopodium cristatum*	1
Small-leaf Goosefoot	*Chenopodium desertorum subsp. microphyllum*	1
Nitre Goosefoot	*Chenopodium nitrariaceum*	6
Windmill Grass	*Chloris spp.*	1
Windmill Grass	*Chloris truncata*	1

Pink Bindweed	*Convolvulus erubescens spp. agg.*	1
Common Cotula	*Cotula australis*	3
Cotula	*Cotula spp.*	2
Dense Crassula	*Crassula colorata*	8
Swamp Crassula	*Crassula helmsii*	1
Purple Crassula	*Crassula peduncularis*	2
Sieber Crassula	*Crassula sieberiana s.l.*	7
Rosinweed	*Cressa australis*	1
Native Scurf-pea	*Cullen australasicum*	1
Hoary Scurf-pea	*Cullen cinereum*	3
Grey Scurf-pea	*Cullen discolor*	1
Woolly Scurf-pea	*Cullen pallidum*	1
Tough Scurf-pea	*Cullen tenax*	3
Golden Dodder	*Cuscuta tasmanica*	1
Couch	*Cynodon dactylon*	2
Native Couch	*Cynodon dactylon var. pulchellus*	2
Variable Flat-sedge	*Cyperus difformis*	3
Tall Flat-sedge	*Cyperus exaltatus*	2
Lax Flat-sedge	*Cyperus flaccidus*	1
Flecked Flat-sedge	*Cyperus gunnii subsp. gunnii*	4
Spiny Flat-sedge	*Cyperus gymnocaulos*	4
Curly Flat-sedge	*Cyperus rigidellus*	2
Bearded Flat-sedge	*Cyperus squarrosus*	1
Yelka	*Cyperus victoriensis*	2
Star Fruit	*Damasonium minus*	1
Wallaby Grass	*Danthonia s.l. spp.*	1
Pale Flax-lily	*Dianella longifolia s.l.*	1
Riverine Flax-lily	*Dianella porracea*	4
Silky Umbrella-grass	*Digitaria ammophila*	3
Rounded Noon-flower	*Disphyma crassifolium subsp. clavellatum*	5
Twin-flower Saltbush	*Dissocarpus biflorus var. biflorus*	1
Slender Hop-bush	*Dodonaea viscosa subsp. angustissima*	1
Globular Pigweed	*Dysphania glomulifera ssp. glomulifera*	1
Yellow Twin-heads	*Eclipta platyglossa*	2

Nodding Saltbush	*Einadia nutans subsp. nutans*	12
Small Elachanth	*Elachanthus pusillus*	1
Waterwort	*Elatine gratioloides*	1
Common Spike-sedge	*Eleocharis acuta*	2
Pale Spike-sedge	*Eleocharis pallens*	1
Small Spike-sedge	*Eleocharis pusilla*	1
Common Wheat-grass	*Elymus scaber var. scaber*	1
Ruby Saltbush	*Enchylaena tomentosa var. tomentosa*	10
Common Bottle-washers	*Enneapogon avenaceus*	1
Spider Grass	*Enteropogon acicularis*	8
Tall Nut-heads	*Epaltes cunninghamii*	7
Cane Grass	*Eragrostis australasica*	1
Common Love-grass	*Eragrostis brownii*	1
Close-headed Love-grass	*Eragrostis diandra*	1
Mallee Love-grass	*Eragrostis dielsii*	5
Southern Cane-grass	*Eragrostis infecunda*	4
Purple Love-grass	*Eragrostis lacunaria*	3
Weeping Love-grass	*Eragrostis parviflora*	1
Bristly Love-grass	*Eragrostis setifolia*	2
Love Grass	*Eragrostis spp.*	1
Spreading Emu-bush	*Eremophila divaricata subsp. divaricata*	22
Common Emu-bush	*Eremophila glabra*	1
Spotted Emu-bush	*Eremophila maculata var. maculata*	4
Woolly-fruit Bluebush	*Eriochiton sclerolaenoides*	1
Blue Heron's-bill	*Erodium crinitum*	1
River Red-gum	*Eucalyptus camaldulensis*	9
Black Box	*Eucalyptus largiflorens*	13
Grey Mallee	*Eucalyptus socialis subsp. socialis*	1
Annual Cudweed	*Euchiton sphaericus*	7
Leafless Ballart	*Exocarpos aphyllus*	1
Pale-fruit Ballart	*Exocarpos strictus*	1
Summer Fringe-sedge	*Fimbristylis aestivalis*	1
Veiled Fringe-sedge	*Fimbristylis velata*	1
Sea Heath	*Frankenia spp.*	1

mallee catchment management authority

Hairy Carpet-weed	*Glinus lotoides*	1
Slender Carpet-weed	*Glinus oppositifolius*	1
Indian Cudweed	*Gnaphalium polycaulon*	1
Silky Goodenia	*Goodenia fascicularis*	1
Pale Goodenia	*Goodenia glauca*	1
Spreading Goodenia	*Goodenia heteromera*	1
Cut-leaf Goodenia	*Goodenia pinnatifida*	1
Small-flower Goodenia	*Goodenia pusilliflora*	1
Goodenia	*Goodenia spp.*	2
Comb Grevillea	*Grevillea huegelii*	3
Silver Needlewood	*Hakea leucoptera subsp. leucoptera*	1
Hooked Needlewood	*Hakea tephrosperma*	1
Rough Raspwort	*Haloragis aspera*	4
Toothed Raspwort	*Haloragis odontocarpa*	1
May Smocks	*Harmsiodoxa blennodioides*	1
Short Cress	*Harmsiodoxa brevipes var. brevipes*	1
Common Heliotrope	*Heliotropium europaeum*	1
Hydrilla	*Hydrilla verticillata*	1
Grass Cushion	*Isoetopsis graminifolia*	3
Inland Club-sedge	*Isolepis australiensis*	1
Broad-fruit Club-sedge	*Isolepis cernua var. platycarpa*	1
Tussock Rush	*Juncus aridicola*	3
Toad Rush	*Juncus bufonius*	2
Gold Rush	*Juncus flavidus*	4
Common Blown-grass	*Lachnagrostis filiformis*	1
Common Blown-grass	*Lachnagrostis filiformis var. 1*	3
Thin Duckweed	*Landoltia punctata*	1
Stalked Plover-daisy	*Leiocarpa websteri*	2
Warty Peppercress	*Lepidium papillosum*	7
Veined Peppercress	*Lepidium phlebopetalum*	1
Native Peppercress	*Lepidium pseudohyssopifolium*	2
Peppercress	*Lepidium spp.*	4
Brown Beetle-grass	*Leptochloa fusca subsp. fusca*	3
Button Rush	*Lipocarpha microcephala*	1

Red Bird's-foot Trefoil	*Lotus cruentus*	1
Clove-strip	*Ludwigia peploides subsp. montevidensis*	2
Box Thorn	*Lycium spp.*	1
Harlequin Mistletoe	*Lysiana exocarpi*	1
Grey Bluebush	*Maireana appressa*	1
Short-leaf Bluebush	*Maireana brevifolia*	2
Black Cotton-bush	*Maireana decalvans*	8
Hairy Bluebush	*Maireana pentagona*	11
Goat Head	*Malacocera tricornis*	1
Narrow-leaf Nardoo	*Marsilea costulifera*	3
Common Nardoo	*Marsilea drummondii*	6
Nardoo	*Marsilea spp.*	3
Moonah	*Melaleuca lanceolata subsp. lanceolata*	1
Bush Minuria	*Minuria cunninghamii*	1
Smooth Minuria	*Minuria integerrima*	8
Blue Rod	*Morgania glabra spp. agg.*	1
Tangled Lignum	*Muehlenbeckia florulenta*	10
Creeping Myoporum	*Myoporum parvifolium*	1
Mousetail	*Myosurus australis*	1
Coarse Water-milfoil	*Myriophyllum caput-medusae*	1
Robust Water-milfoil	*Myriophyllum papillosum*	1
Water-milfoil	*Myriophyllum spp.*	3
Red Water-milfoil	*Myriophyllum verrucosum*	1
Water Nymph	*Najas tenuifolia*	1
Pimelea Daisy-bush	*Olearia pimeleoides*	1
Austral Adder's-tongue	*Ophioglossum lusitanicum*	1
Upright Adder's-tongue	*Ophioglossum polyphyllum*	3
Babbagia	*Osteocarpum acropterum var. deminutum*	1
Bonefruit	*Osteocarpum salsuginosum*	1
Swamp Lily	*Ottelia ovalifolia subsp. ovalifolia*	1
Grassland Wood-sorrel	*Oxalis perennans*	2
Wood Sorrel	*Oxalis spp.*	1
Hairy Panic	*Panicum effusum*	2
Knottybutt Grass	*Paspalidium constrictum*	1

Warrego Summer-grass	*Paspalidium jubiflorum*	5
Slender Knotweed	*Persicaria decipiens*	2
Common Reed	*Phragmites australis*	1
Sandhill Spurge	*Phyllanthus lacunellus*	1
Earth Moss	*Physcomitrella patens subsp. readeri*	1
Austral Pillwort	*Pilularia novae-hollandiae*	1
Weeping Pittosporum	*Pittosporum angustifolium*	2
Clay Plantain	*Plantago cunninghamii*	2
Plantain	*Plantago spp.*	1
Crowned Plantain	*Plantago turrifera*	2
Forde Poa	*Poa fordeana*	2
Poached-eggs Daisy	*Polycalymma stuartii*	1
Curly Pondweed	*Potamogeton crispus*	1
Blunt Pondweed	*Potamogeton ochreatus*	1
Fennel Pondweed	*Potamogeton pectinatus*	1
Perfoliate Pondweed	*Potamogeton perfoliatus s.l.*	1
Floating Pondweed	*Potamogeton tricarinatus s.l.*	2
Jersey Cudweed	*Pseudognaphalium luteoalbum*	6
Spiny Mud-grass	*Pseudoraphis spinescens*	1
Yellow Tails	*Ptilotus nobilis var. nobilis*	2
Long Tails	*Ptilotus polystachyus var. polystachyus*	1
Crimson Tails	*Ptilotus sessilifolius var. sessilifolius*	1
Inland Buttercup	*Ranunculus pentandrus var. platycarpus*	1
Hedge Saltbush	*Rhagodia spinescens*	2
Paper Sunray	*Rhodanthe corymbiflora*	1
Slender Dock	*Rumex brownii*	2
Narrow-leaf Dock	*Rumex tenax*	1
Prickly Saltwort	*Salsola tragus*	1
Prickly Saltwort	*Salsola tragus subsp. tragus*	3
Beaded Glasswort	*Sarcocornia quinqueflora*	1
Sarcozona	*Sarcozona praecox*	1
Prickly Fan-flower	*Scaevola spinescens*	1
River Club-sedge	*Schoenoplectus tabernaemontani*	3
Short-wing Saltbush	*Sclerochlamys brachyptera*	9

Grey Copperburr	*Sclerolaena diacantha*	3
Black Roly-poly	*Sclerolaena muricata*	2
Spear-fruit Copperburr	*Sclerolaena patenticuspis*	1
Streaked Copperburr	*Sclerolaena tricuspis*	5
Slender Groundsel	*Senecio glossanthus s.l.*	10
Cotton Fireweed	*Senecio quadridentatus*	1
Desert Cassia	*Senna artemisioides spp. agg.*	1
Variable Sida	*Sida corrugata*	1
Pin Sida	*Sida fibulifera*	1
Twiggy Sida	*Sida intricata*	1
Sida	*Sida spp.*	1
Narrow-leaf Sida	*Sida trichopoda*	1
Quena	*Solanum esuriale*	1
Lesser Sea-spurrey	*Spergularia marina s.s.*	1
Salt Sea-spurrey	*Spergularia sp. 3*	2
Spreading Nut-heads	*Sphaeromorphaea australis*	1
Rat-tail Couch	*Sporobolus mitchellii*	21
Star Bluebush	*Stelligera endecaspinis*	4
Small-leaf Swainson-pea	*Swainsona microphylla*	1
Dwarf Swainson-pea	*Swainsona phacoides*	1
Silky Swainson-pea	*Swainsona sericea*	1
Desert Spinach	*Tetragonia eremaea s.l.*	1
Annual Spinach	*Tetragonia moorei*	1
Grey Germander	*Teucrium racemosum s.l.*	3
Grey Germander	*Teucrium racemosum s.s.*	1
Caltrop	*Tribulus terrestris*	1
Spurred Arrowgrass	*Triglochin calcitrapa s.l.*	1
Porcupine Grass	*Triodia scariosa*	1
Needle Grass	*Triraphis mollis*	1
Narrow-leaf Cumbungi	*Typha domingensis*	1
Bullrush	*Typha spp.*	1
Eel Grass	*Vallisneria americana var. americana*	2
Common Verbena	*Verbena officinalis s.l.*	1
Annual New Holland Daisy	*Vittadinia cervicularis*	1

Annual New Holland Daisy	*Vittadinia cervicularis var. subcervicularis*	1
Fuzzy New Holland Daisy	*Vittadinia cuneata*	1
Dissected New Holland Daisy	*Vittadinia dissecta s.l.*	2
New Holland Daisy	*Vittadinia spp.*	1
River Bluebell	*Wahlenbergia fluminalis*	4
Annual Bluebell	*Wahlenbergia gracilenta s.l.*	1
Bluebell	*Wahlenbergia spp.*	1
Green-tufted Stubble-moss	*Weissia controversa*	1
Common Early Nancy	*Wurmbea dioica*	1
Sand Twin-leaf	*Zygophyllum ammophilum*	2
Scrambling Twin-leaf	*Zygophyllum angustifolium*	1
Pointed Twin-leaf	*Zygophyllum apiculatum*	3
Pale Twin-leaf	*Zygophyllum glaucum*	3
Twin-leaf	*Zygophyllum spp.*	4

Flora – Exotic

Common Name	Scientific Name	Records
Orange Fox-tail	*Alopecurus aequalis*	1
Bridal Creeper	*Asparagus asparagoides*	1
Asparagus	*Asparagus officinalis*	2
Onion Weed	*Asphodelus fistulosus*	2
Aster-weed	*Aster subulatus*	9
Hastate Orache	*Atriplex prostrata*	1
Bearded Oat	*Avena barbata*	2
Oat	*Avena spp.*	2
Mediterranean Turnip	*Brassica tournefortii*	1
Lesser Quaking-grass	*Briza minor*	1
Great Brome	*Bromus diandrus*	2
Red Brome	*Bromus rubens*	7
Ward's Weed	*Carrichtera annua*	1
Malta Thistle	*Centaurea melitensis*	1
Rhodes Grass	*Chloris gayana*	1
Spear Thistle	*Cirsium vulgare*	2
Camel Melon	*Citrullus lanatus*	1

Common Name	Scientific Name	Records
Water Buttons	*Cotula coronopifolia*	2
Paddy Melon	*Cucumis myriocarpus subsp. leptodermis*	1
Couch	*Cynodon dactylon var. dactylon*	1
Drain Flat-sedge	*Cyperus eragrostis*	1
Curry Flat-sedge	*Cyperus hamulosus*	1
Nutgrass	*Cyperus rotundus*	1
Stinkwort	*Dittrichia graveolens*	1
Barnyard Grass	*Echinochloa crus-galli*	1
Water Hyacinth	*Eichhornia crassipes*	1
Spiny Emex	*Emex australis*	1
Stink Grass	*Eragrostis cilianensis*	1
Fumitory	*Fumaria spp.*	1
Northern Barley-grass	*Hordeum glaucum*	4
Barley-grass	*Hordeum leporinum*	1
Barley-grass	*Hordeum murinum s.l.*	1
Smooth Cat's-ear	*Hypochoeris glabra*	14
Flatweed	*Hypochoeris radicata*	1
Spiny Rush	*Juncus acutus subsp. acutus*	1
Willow-leaf Lettuce	*Lactuca saligna*	1
Prickly Lettuce	*Lactuca serriola*	4
Golden-top	*Lamarckia aurea*	2
Common Peppercress	*Lepidium africanum*	1
Hoary Cress	*Lepidium draba*	4
Wimmera Rye-grass	*Lolium rigidum*	3
Horehound	*Marrubium vulgare*	1
Little Medic	*Medicago minima*	3
Burr Medic	*Medicago polymorpha*	4
Lucerne	*Medicago sativa subsp. sativa*	1
Bokhara Clover	*Melilotus albus*	1
Sweet Melilot	*Melilotus indicus*	1
Melilot	*Melilotus spp.*	1
Common Ice-plant	*Mesembryanthemum crystallinum*	2
Small Ice-plant	*Mesembryanthemum nodiflorum*	1

Common Name	Scientific Name	Records
Common Evening-primrose	*Oenothera stricta subsp. stricta*	1
Soursob	*Oxalis pes-caprae*	1
Coast Barb-grass	*Parapholis incurva*	1
Paspalum	*Paspalum dilatatum*	1
Water Couch	*Paspalum distichum*	5
Fog-fruit	*Phyla canescens*	15
Rice Millet	*Piptatherum miliaceum*	2
Ribwort	*Plantago lanceolata*	1
Prostrate Knotweed	*Polygonum aviculare s.l.*	1
Annual Beard-grass	*Polypogon monspeliensis*	1
Wiry Noon-flower	*Psilocaulon granulicaule*	2
False Sow-thistle	*Reichardia tingitana*	4
Tiny Bristle-grass	*Rostraria pumila*	6
Wild Sage	*Salvia verbenaca*	2
Arabian Grass	*Schismus barbatus*	4
Whorled Pigeon-grass	*Setaria verticillata*	1
Mallee Catchfly	*Silene apetala var. apetala*	4
Smooth Mustard	*Sisymbrium erysimoides*	3
London Rocket	*Sisymbrium irio*	1
Rough Sow-thistle	*Sonchus asper s.l.*	3
Common Sow-thistle	*Sonchus oleraceus*	16
Lesser Sand-spurrey	*Spergularia diandra*	2
Red Sand-spurrey	*Spergularia rubra s.l.*	2
Cluster Clover	*Trifolium glomeratum*	1
Woolly Clover	*Trifolium tomentosum var. tomentosum*	3
Arrowleaf Clover	*Trifolium vesiculosum var. vesiculosum*	2
Small Nettle	*Urtica urens*	1
Common Vetch	*Vicia sativa*	1
Rat's-tail Fescue	*Vulpia myuros*	4
Rat's-tail Fescue	*Vulpia myuros f. myuros*	3
Bathurst Burr	*Xanthium spinosum*	1
Noogoora Burr species	*Xanthium strumarium spp. agg.*	1

Fauna – Native

Common Name	Scientific Name	Type	Records
Freshwater Shrimp	*Paratya australiensis*	I	1
Inland River Prawn	*Macrobrachium australiense*	I	1
Unspecked Hardyhead	*Craterocephalus stercusmuscarum fulvus*	F	3
Golden Perch	*Macquaria ambigua*	F	1
Western Carp Gudgeon	*Hypseleotris klunzingeri*	F	3
Flat-headed Gudgeon	*Philypnodon grandiceps*	F	4
Little Pied Cormorant	*Microcarbo melanoleucos*	B	30
Pied Butcherbird	*Cracticus nigrogularis*	B	16
Brown Quail	*Coturnix ypsilophora australis*	B	1
Little Button-quail	*Turnix velox*	B	1
Peaceful Dove	*Geopelia striata*	B	17
Common Bronzewing	*Phaps chalcoptera*	B	16
Crested Pigeon	*Ocyphaps lophotes*	B	21
Buff-banded Rail	*Gallirallus philippensis*	B	1
Australian Spotted Crake	*Porzana fluminea*	B	3
Baillon's Crake	*Porzana pusilla palustris*	B	3
Spotless Crake	*Porzana tabuensis*	B	1
Black-tailed Native-hen	*Gallinula ventralis*	B	3
Dusky Moorhen	*Gallinula tenebrosa*	B	10
Purple Swamphen	*Porphyrio porphyrio*	B	11

Common Name	Scientific Name	Type	Records
Eurasian Coot	*Fulica atra*	B	33
Australasian Grebe	*Tachybaptus novaehollandiae*	B	11
Hoary-headed Grebe	*Poliocephalus poliocephalus*	B	17
Great Cormorant	*Phalacrocorax carbo*	B	17
Little Black Cormorant	*Phalacrocorax sulcirostris*	B	23
Pied Cormorant	*Phalacrocorax varius*	B	10
Darter	*Anhinga novaehollandiae*	B	30
Australian Pelican	*Pelecanus conspicillatus*	B	49
Whiskered Tern	*Chlidonias hybridus javanicus*	B	3
Caspian Tern	*Hydroprogne caspia*	B	15
Silver Gull	*Chroicocephalus novaehollandiae*	B	10
Red-kneed Dotterel	*Erythrogonys cinctus*	B	3
Masked Lapwing	*Vanellus miles*	B	19
Banded Lapwing	*Vanellus tricolor*	B	1
Red-capped Plover	*Charadrius ruficapillus*	B	4
Black-fronted Dotterel	*Elseyornis melanops*	B	10
Red-necked Avocet	*Recurvirostra novaehollandiae*	B	2
Common Greenshank	*Tringa nebularia*	B	1
Marsh Sandpiper	*Tringa stagnatilis*	B	1
Curlew Sandpiper	*Calidris ferruginea*	B	1
Sharp-tailed Sandpiper	*Calidris acuminata*	B	2

Common Name	Scientific Name	Type	Records
Bush Stone-curlew	*Burhinus grallarius*	B	1
Australian White Ibis	*Threskiornis molucca*	B	18
Straw-necked Ibis	*Threskiornis spinicollis*	B	6
Royal Spoonbill	*Platalea regia*	B	1
Yellow-billed Spoonbill	*Platalea flavipes*	B	14
Little Egret	*Egretta garzetta nigripes*	B	1
Intermediate Egret	*Ardea intermedia*	B	1
Eastern Great Egret	*Ardea modesta*	B	23
White-faced Heron	*Egretta novaehollandiae*	B	28
White-necked Heron	*Ardea pacifica*	B	7
Nankeen Night Heron	*Nycticorax caledonicus hillii*	B	1
Little Bittern	*Ixobrychus minutus dubius*	B	2
Australian Wood Duck	*Chenonetta jubata*	B	33
Black Swan	*Cygnus atratus*	B	61
Plumed Whistling-Duck	*Dendrocygna eytoni*	B	1
Australian Shelduck	*Tadorna tadornoides*	B	51
Pacific Black Duck	*Anas superciliosa*	B	69
Chestnut Teal	*Anas castanea*	B	4
Grey Teal	*Anas gracilis*	B	64
Australasian Shoveler	*Anas rhynchotis*	B	4
Pink-eared Duck	*Malacorhynchus membranaceus*	B	2

Common Name	Scientific Name	Type	Records
Freckled Duck	*Stictonetta naevosa*	B	5
Hardhead	*Aythya australis*	B	5
Blue-billed Duck	*Oxyura australis*	B	2
Musk Duck	*Biziura lobata*	B	8
Swamp Harrier	*Circus approximans*	B	17
Brown Goshawk	*Accipiter fasciatus*	B	2
Little Eagle	*Hieraaetus morphnoides*	B	5
White-bellied Sea-Eagle	*Haliaeetus leucogaster*	B	1
Whistling Kite	*Haliastur sphenurus*	B	24
Black Kite	*Milvus migrans*	B	8
Australian Hobby	*Falco longipennis*	B	4
Grey Falcon	*Falco hypoleucos*	B	1
Peregrine Falcon	*Falco peregrinus*	B	1
Nankeen Kestrel	*Falco cenchroides*	B	6
Southern Boobook	*Ninox novaeseelandiae*	B	1
Sulphur-crested Cockatoo	*Cacatua galerita*	B	2
Major Mitchell's Cockatoo	*Lophocroa leadbeateri*	B	1
Little Corella	*Cacatua sanguinea*	B	3
Long-billed Corella	*Cacatua tenuirostris*	B	1
Galah	*Eolophus roseicapilla*	B	13
Regent Parrot	*Polytelis anthopeplus monarchoides*	B	3

Common Name	Scientific Name	Type	Records
Crimson Rosella	*Platycercus elegans*	B	27
Red-rumped Parrot	*Psephotus haematonotus*	B	30
Tawny Frogmouth	*Podargus strigoides*	B	2
Laughing Kookaburra	*Dacelo novaeguineae*	B	22
Sacred Kingfisher	*Todiramphus sanctus*	B	16
Rainbow Bee-eater	*Merops ornatus*	B	3
Pallid Cuckoo	*Cuculus pallidus*	B	4
Black-eared Cuckoo	*Chrysococcyx osculans*	B	1
Horsfield's Bronze-Cuckoo	*Chrysococcyx basalis*	B	3
Welcome Swallow	*Petrochelidon neoxena*	B	25
Tree Martin	*Petrochelidon nigricans*	B	12
Fairy Martin	*Petrochelidon ariel*	B	1
Grey Fantail	*Rhipidura albiscarpa*	B	4
Willie Wagtail	*Rhipidura leucophrys*	B	31
Restless Flycatcher	*Myiagra inquieta*	B	1
Red-capped Robin	*Petroica goodenovii*	B	9
Hooded Robin	*Melanodryas cucullata cucullata*	B	7
Rufous Whistler	*Pachycephala rufiventris*	B	17
Grey Shrike-thrush	*Colluricincla harmonica*	B	21
Magpie-lark	*Grallina cyanoleuca*	B	27
Crested Shrike-tit	*Falcunculus frontatus*	B	1

Common Name	Scientific Name	Type	Records
Crested Bellbird	*Oreoica gutturalis gutturalis*	B	1
Black-faced Cuckoo-shrike	*Coracina novaehollandiae*	B	14
White-bellied Cuckoo-shrike	*Coracina papuensis*	B	1
White-winged Triller	*Lalage sueurii*	B	3
White-browed Babbler	*Pomatostomus superciliosus*	B	3
Chestnut-crowned Babbler	*Pomatostomus ruficeps*	B	3
White-fronted Chat	*Epthianura albifrons*	B	1
Crimson Chat	*Epthianura tricolor*	B	1
Western Gerygone	*Gerygone fusca*	B	1
Weebill	*Smicrornis brevirostris*	B	17
Southern Whiteface	*Aphelocephala leucopsis*	B	3
Yellow Thornbill	*Acanthiza nana*	B	3
Chestnut-rumped Thornbill	*Acanthiza uropygialis*	B	8
Buff-rumped Thornbill	*Acanthiza reguloides*	B	1
Yellow-rumped Thornbill	*Acanthiza chrysorrhoa*	B	3
Rufous Songlark	*Cincloramphus mathewsi*	B	1
Little Grassbird	*Megalurus gramineus*	B	3
Clamorous Reed Warbler	*Acrocephalus stentoreus*	B	20
Superb Fairy-wren	*Malurus cyaneus*	B	12
Variegated Fairy-wren	*Malurus lamberti*	B	9
White-breasted Woodswallow	*Artamus leucorynchus*	B	4

Common Name	Scientific Name	Type	Records
Masked Woodswallow	*Artamus personatus*	B	3
White-browed Woodswallow	*Artamus superciliosus*	B	4
Dusky Woodswallow	*Artamus cyanopterus*	B	12
White-browed Treecreeper	*Climacteris affinis*	B	3
Mistletoebird	*Dicaeum hirundinaceum*	B	8
Spotted Pardalote	*Pardalotus punctatus*	B	1
Silvereye	*Zosterops lateralis*	B	1
Brown-headed Honeyeater	*Melithreptus brevirostris*	B	1
Striped Honeyeater	*Plectorhyncha lanceolata*	B	1
White-fronted Honeyeater	*Phylidonyris albifrons*	B	1
Painted Honeyeater	*Grantiella picta*	B	1
White-plumed Honeyeater	*Lichenostomus penicillatus*	B	27
Noisy Miner	*Manorina melanocephala*	B	29
Yellow-throated Miner	*Manorina flavigula*	B	1
Red Wattlebird	*Anthochaera carunculata*	B	5
Spiny-cheeked Honeyeater	*Acanthagenys rufogularis*	B	3
Blue-faced Honeyeater	*Entomyzon cyanotis*	B	7
Noisy Friarbird	*Philemon corniculatus*	B	1
Little Friarbird	*Philemon citreogularis*	B	15
Zebra Finch	*Taeniopygia guttata*	B	3
Apostlebird	*Struthidea cinerea*	B	2

Common Name	Scientific Name	Type	Records
Little Crow	*Corvus bennetti*	B	1
White-winged Chough	*Corcorax melanorhamphos*	B	8
Grey Butcherbird	*Cracticus torquatus*	B	2
Australian Magpie	*Gymnorhina tibicen*	B	26
Australian Raven	*Corvus coronoides*	B	17
Rock Dove	*Columba livia*	B	11
Striated Pardalote	*Pardalotus striatus*	B	13
Common Brushtail Possum	*Trichosurus vulpecula*	M	2
Western Grey Kangaroo	*Macropus fuliginosus*	M	1
Inland Broad-nosed Bat	*Scotorepens balstoni*	M	1
Water Rat	*Hydromys chrysogaster*	M	2
Tree Dtella	*Gehyra variegata*	R	1
Bynoe's Gecko	*Heteronotia binoei*	R	1
Beaked Gecko	*Rhynchoedura ornata*	R	
Lace Monitor	*Varanus varius*	R	1
Dwarf Burrowing Skink	*Lerista timida*	R	1
Boulenger's Skink	*Morethia boulengeri*	R	6
Mueller's Skink	*Lerista muelleri*	R	1
Western Blue-tongued lizard	*Tiliqua occipitatis*	R	
Stumpy-tailed Lizard	*Tiliqua rugosa*	R	1
Lined Earless Dragon	*Tympanocryptis lineata lineata*	R	

Common Name	Scientific Name	Type	Records
Yellow-faced Whip Snake	*Demansia psammophis*	R	1
Tiger Snake	*Notechis scutatus*	R	4
Eastern Brown Snake	*Pseudonaja textilis*	R	1
Curl Snake	*Suta suta*	R	1
Broad-shelled Turtle	*Macrochelodina expansa*	R	10
Commong Long-necked Turtle	*Chelodina longicollis*	R	4
Murray River Turtle	*Emydura macquarji*	R	21
Southern Bullfrog (ssp. unknown)	*Limnodynastes dumerilii*	A	2
Barking Marsh Frog	*Limnodynastes fletcheri*	A	4
Spotted Marsh Frog (race unknown)	*Limnodynastes tasmaniensis*	A	11
Plains Froglet	*Crinia parinsignifera*	A	7
Peron's Tree Frog	*Litoria peronii*	A	4
Growling Grass Frog	*Litoria raniformis*	A	3
Yellow Rosella	*Platycercus elegans flaveolus*	B	8
Brown Treecreeper (south-eastern ssp.)	*Climacteris picumnus victoriae*	B	20
Carpet Python	*Morelia spilota metcalfei*	R	1
Silver Perch	*Bidyanus bidyanus*	F	1
Crimson-spotted Rainbowfish	*Melanotaenia fluviatilis*	F	
Freshwater Catfish	*Tandanus tandanus*	F	5
Black-winged Stilt	*Himantopus himantopus*	B	2

Legend
Type: Invertebrate, Fish, Amphibian, Reptile, Bird, Mammal

Fauna – Exotic

Common Name	Scientific Name	Type	Records
Common Starling	*Sturnus vulgaris*	B	4
House Sparrow	*Passer domesticus*	B	3
Common Blackbird	*Turdus merula*	B	2
Northern Mallard	*Anas platyrhynchos*	B	1
European Goldfinch	*Carduelis carduelis*	B	1
European Rabbit	*Oryctolagus cuniculus*	M	1
European Hare	*Lepus europeaus*	M	2
Redfin	*Perca fluviatilis*	F	1
Goldfish	*Carassius auratus*	F	1
Eastern Gambusia	*Gambusia holbrooki*	F	1
Red Fox	*Vulpes vulpes*	M	1

Legend
Type: Invertebrate, Fish, Amphibian, Reptile, Bird, Mammal

Appendix 2. Ecological vegetation classes

Appendix 2 provides a description of each EVC in the Psyche Woorlong WMU

EVC no.	EVC name	Bioregional Conservation Status Robinvale Plains Bioregion	Description
106	Grassy Riverine Forest	Depleted	Occurs on the floodplain of major rivers, in a slightly elevated position where floods are infrequent, on deposited silts and sands, forming fertile alluvial soils. River Red Gum forest to 25 m tall with a groundlayer dominated by tussock-forming graminoids. Occasional tall shrubs present.
813	Intermittent Swampy Woodland	Depleted	Eucalypt woodland to 15 m tall with a variously shrubby and rhizomatous sedgy - turf grass understorey, at best development dominated by flood stimulated species in association with flora tolerant of inundation. Flooding is unreliable but extensive when it happens. Occupies low elevation areas on river terraces (mostly at the rear of point-bar deposits or adjacent to major floodways) and lacustrine verges (where sometimes localised to narrow transitional bands). Soils often have a shallow sand layer over heavy and frequently slightly brackish soils.
808	Lignum Shrubland	Least concern	Relatively open shrubland of species of divaricate growth form. The ground-layer is typically herbaceous or a turf grassland, rich in annual/ephemeral herbs and small chenopods. Characterised the open and even distribution of relatively small Lignumshrubs. Occupies heavy soil plains along Murray River, low-lying areas on higher-level (but still potentially flood-prone) terraces.
103	Riverine Chenopod Woodland	Depleted	Eucalypt woodland to 15 m tall with a diverse shrubby and grassy understorey occurring on most elevated riverine terraces. Confined to heavy clay soils on higher level terraces within or on the margins of riverine floodplains (or former floodplains), naturally subject to only extremely infrequent incidental shallow flooding from major events if at all flooded.

819	Spike-sedge Wetland	Vulnerable	Low sedgy vegetation of species-poor seasonal or intermittent wetlands, dominated by spike-sedges. Typically treeless, but sometimes thickets of saplings or scattered more mature specimens of Eucalyptus camaldulensis. Mostly confined to a narrow ring around the upper margins of floodway ponds. Soils are typically heavy clays (eg mottled yellow-grey clay, grey loamy clay), occasionally silty near the surface. In some riverine sites, annual inundation is not reliable and the rhizomic rootstocks of Eleocharis acuta appear capable of surviving at least occasional periods of longer dormancy.
821	Tall Marsh	Depleted	Wetland dominated by tall emergent graminoids (rushes, sedges, reeds), typically in thick species-poor swards. Competitive exclusion in core wetland habitat - of optimum growing conditions for species tolerant of sustained shallow inundation. Occupies wetlands usually associated with anabranch creeks. Soils are almost permanently moist. Dominant species are tolerant of relatively deep and sustained inundation, but not total immersion for any sustained period.
823	Lignum Swampy Woodland	Depleted	Understorey dominated by Lignum, typically of robust character and relatively dense (at least in patches), in association with a low Eucalypt and/or Acacia woodland to 15 m tall. The ground layer includes a component of obligate wetland flora that is able to persist even if dormant over dry periods.
104	Lignum Swamp	Vulnerable	A relatively heterogenous group of species-poor wetlands dominated by robust and often dense lignum. Scattered in lower rainfall areas of north and west, including rain-shadow areas on basalt.
102	Low Chenopod Shrubland	Depleted	Sparse, low non-eucalypt woodland to 12m tall of the arid zone with a tall open chenopod shrub-dominated understorey to a treeless, tall chenopod shrubland to 3m tall. This EVC may occur as either a woodland (typically with a very open structure but tree cover >10%) or a shrubland (tree cover <10%) with trees as occasional emergent.
97	Semi-arid Woodland	Vulnerable	Non-eucalypt woodland or open forest to 12m tall, of low rainfall areas. Occurs in a range of somewhat elevated positions not subject to flooding or inundation. The surface soils are typically light textured loamy sands or sandy loams.
98	Semi-arid Chenopod Woodland	Vulnerable	Sparse, low non-eucalypt woodland to 12m tall of the arid zone with a tall open chenopod shrub-dominated understorey to a treeless, tall chenopod shrubland to 3m tall. This EVC may occur as either a woodland (typically with a very open structure but tree cover >10%) or a shrubland (tree cover <10%) with trees as an occasional emergent.

Appendix 3. Cultural heritage contingency plan

CONTINGENCY PLANS

In the event that Aboriginal cultural heritage is found during the conduct of the activity, contingency measures are set out below. The contingency measures set out the sponsor's requirements in the event that Aboriginal cultural heritage is identified during the conduct of the activity.

1 Management of Aboriginal Cultural Heritage found during the Activity

In the event that new Aboriginal cultural heritage is found during the conduct of the activity, then the following must occur:

- The person who discovers Aboriginal cultural heritage during the activity will immediately notify the person in charge of the activity;
- The person in charge of the activity must then suspend any relevant works at the location of the discovery and within 5m of the relevant place extent;
- In order to prevent any further disturbance, the location will be isolated by safety webbing or an equivalent barrier and works may recommence outside the area of exclusion;
- The person in charge of the activity must contact the and the Mallee CMA Indigenous Facilitator
- Within a period not exceeding 1 working days a decision/ recommendation will be made by the Mallee CMA Indigenous Facilitator and the Aboriginal stakeholder;
- As to the process to be followed to manage the Aboriginal cultural heritage in a culturally appropriate manner, and how to proceed with the works;

Separate contingency plan has been developed in the event that suspected human remains are discovered during the conduct of the activity.

2 Notification of the Discovery of Skeletal Remains during the carrying out of the Activity

1. Discovery:

- If suspected human remains are discovered, all activity in the vicinity must stop to ensure minimal damage is caused to the remains, and,
- The remains must be left in place, and protected from harm or damage.

2. Notification:

- Once suspected human skeletal remains have been found, Victoria Police (use the local number) and the Coroner's Office (1300 309 519) must be notified immediately;
- If there is reasonable grounds to believe that the remains could be Aboriginal, the DSE Emergency Co-ordination Centre must be immediately notified on 1300 888 544; and
- All details of the location and nature of the human remains must be provided to the relevant authorities.

- If it is confirmed by these authorities that the discovered remains are Aboriginal skeletal remains, the person responsible for the activity must report the existence of the human remains to the Secretary, DPCD in accordance with s.17 of the Act.

3. Impact Mitigation or Salvage:

- The Secretary, after taking reasonable steps to consult with any Aboriginal person or body with an interest in the Aboriginal human remains, will determine the appropriate course of action as required by s.18(2)(b) of the Act.
- An appropriate impact mitigation or salvage strategy as determined by the Secretary must be implemented.

4. Curation and Further Analysis:

- The treatment of salvaged Aboriginal human remains must be in accordance with the direction of the Secretary.

5. Reburial:

- Any reburial site(s) must be fully documented by an experienced and qualified archaeologist, clearly marked and all details provide to AAV;

Appropriate management measures must be implemented to ensure that the remains are not disturbed in the future.