Merbein Common Environmental Water Management Plan

mallee
catchment management authority

Document Control

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Contact

For queries regarding this document, please contact:

Louise Chapman

Louise.Chapman@malleecma.com.au

Waterways Coordinator

Mallee Catchment Management Authority

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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) identified 23 Waterway Management Units (WMU) from 216 targeted waterways in the Mallee. The interconnectedness and commonality of threats impacting on the waterway values were used to group the WMUs into planning units. This EWMP has been developed for the Merbein Common WMU sub-unit, hereafter referred to as Merbein Common. The EWMP will help to guide future environmental watering activities for this area.

Merbein Common is located within the Merbein WMU, 15km north west of Mildura on the Murray River floodplain. Two wetlands within the system, Cowanna Billabong and Brickworks Billabong, have been disconnected from the River Murray by a large bank which historically allowed Brickworks Billabong to be used as an irrigation drainage disposal basin. Cowanna Billabong is a freshwater lagoon and Brickworks Billabong is highly salinised with salinity reaching up to 50,000 EC. Cowanna and Brickworks Billabong are regulated and managed for environmental outcomes. A third wetland at Merbein Common is Catfish Billabong which is currently inundated by the Lock 10 – Wentworth Weir. Catfish Billabong transitions from a freshwater wetland near the Murray River to a more salinised environment further into the floodplain. Cowanna Billabong, Brickworks Billabong and Catfish Billabong form the target area for this EWMP.

Merbein Common is Murray River Reserve and Murray River Park. It is popular for recreational activities including walking, bird watching and fishing. Merbein Common has significant Indigenous and European cultural heritage values.

Merbein Common is a significant site for environmental watering due to its high rehabilitation potential and its significance as a relocation site for Murray Hardyhead. The three wetlands within the target area offer a significant variety of habitats for waterbirds and both small and large-bodied native fish. The site has high visitor numbers and has important value in educating the community on environmental values and environmental watering.

The management goal for the Merbein EWMP is “to provide a water regime for Cowanna Billabong and Catfish Billabong that will support a diverse fish and bird community through high levels of aquatic productivity. Brickworks Billabong will be a significant site for the conservation of Murray Hardyhead.”

To achieve the management goals, ecological and hydrological objectives have been defined to provide an appropriate environmental watering regime. The ecological objectives for Merbein Common are:

Cowanna and Catfish Billabongs

- Diverse large and small-bodied native fish community
- Provide productive feeding habitat for large wading birds
- Maintain high levels of aquatic productivity
- Extensive submerged aquatic macrophytes such as *Potomegeton* spp. and emergent macrophyte community
- Diverse fringing emergent macrophyte community over a broad littoral zone

Catfish Billabong

- Inundate Intermittent Swampy Woodland vegetation to provide foraging and resting habitat for large waders

Brickworks Billabong

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

The optimal water regime for each of the wetlands is provided below.

Cowanna Billabong

Maintain Cowanna Billabong as a permanent freshwater wetland, with seasonal variable water levels. Fill/top up Cowanna Billabong annually in late winter/ early spring to 31.65m AHD, allowing natural drawdown of the water level over summer/autumn. Ensure that permanent open water habitat is maintained by ensuring that water levels do not fall below 29.5m AHD.

Brickworks Billabong

Maintain Brickworks Billabong as a permanent saline wetland, with seasonally variable water levels. Fill/top up Brickworks Billabong annually in spring (August to October) to 34m AHD, allow the water level to decrease through late summer/autumn to a minimum of 33m AHD. Ensure that water level will maintain inundation of *Ruppia spp.* beds.

Catfish Billabong

Maintain Catfish Billabong as a permanent freshwater wetland, with seasonal variation in water levels. Surcharge Catfish Billabong via pumping to 33.5m AHD every second year in late winter/ early spring to inundate fringing woodland, then allow water levels to recede through summer/autumn. Ensure that aquatic habitat is retained by maintaining water levels at 30.8 m AHD in every year.

A drying phase is to be introduced only as a Carp management tool for Cowanna and Catfish billabongs. This should be enacted when there is evidence of abundant large Carp, or obvious decline in submergent macrophyte communities as a result of Carp.

New infrastructure is required to enable the efficient and effective delivery of environmental water to Brickworks Billabong and Catfish Billabong. Infrastructure is already in place for Cowanna Billabong.

The salinity tolerances of adult Murray Hardyhead are known, however the tolerances of Murray Hardyhead eggs and larvae are currently unknown. This is a significant knowledge gap for the EWMP. Research to confirm these tolerances would better inform management at Brickworks Billabong, by allowing managers to target water quality conditions which are suitable for Murray Hardyhead breeding and recruitment, but inhibit the survival of predatory fish.

1 Introduction

This Environmental Water Management Plan (EWMP) has been prepared by the Mallee Catchment Management Authority (CMA) to establish the long-term management goals of Merbein Common.

The key purposes of the EWMP are to:

- identify long-term objectives and water requirements for the wetlands, identified as a high priority by the Mallee 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 the long-term watering plans to be developed under the Basin Plan requirements.

2 Site overview

2.1 Site location

The Mallee CMA region is situated in the north-west of Victoria. The area of responsibility is close to 39,000 km^2 (3.9 million ha) and has a regional population estimated to be 65,000. Population centres include Mildura, Birchip, Sea Lake, Ouyen, Robinvale, Red Cliffs and Merbein.

The boundaries of the Mallee CMA region cover almost one fifth of Victoria, making it the largest area managed by a CMA in the state.

Approximately 40% of the land area within the Mallee CMA boundary is public land, consisting mainly of national parks, reserves, wilderness, and large areas of riverine and dryland forests. The other 60% is predominantly dryland crops, but there is also a significant investment in irrigated horticulture including grapes, citrus, almonds, olives and vegetables along the Murray River corridor. Irrigated crops contribute over 40% of the value of agricultural production for the region.

In 2006, the Mallee CMA engaged consultants (Ecological Associates, 2006) 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, but which are relatively consistent in their ecological values and land uses. The Mallee CMA has based its environmental water management plans on these FMUs to support 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 (WMUs) for planning within its Mallee Waterway Strategy.

The site for this plan is the Merbein Common FMU, hereafter referred to as Merbein Common in this document. Merbein Common is located within the Merbein WMU, 15km north west of Mildura on the Murray River floodplain (Figure 1).

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

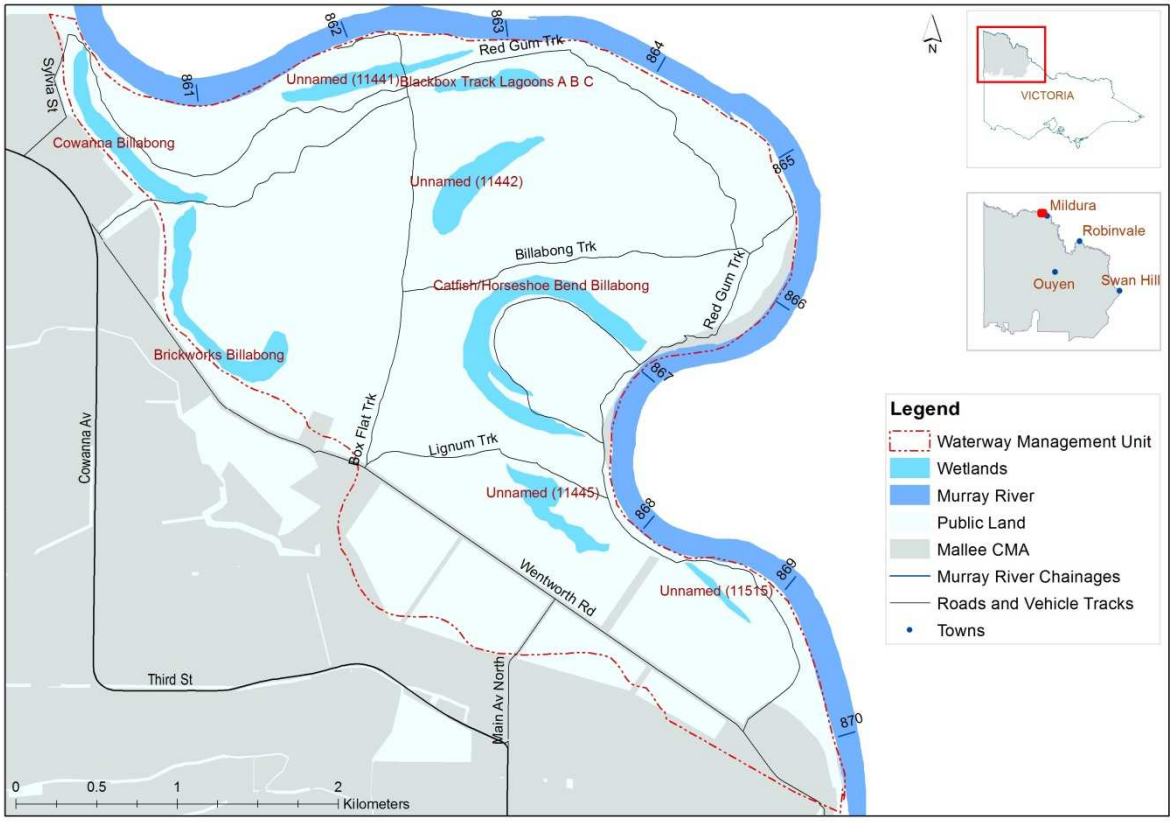


Figure 1 – Merbein Common

2.2 Catchment setting

Merbein Common is in the Murray Scroll Belt bioregion within the Mallee CMA region. The bioregion is characterised by an entrenched river valley and associated floodplain and lake complexes of numerous oxbow lakes, billabongs, ephemeral lakes, swamps and active meander belts. Alluvial deposits from the Cainozoic period gave rise to the red brown earths, cracking clays and texture contrast soils (Dermosols, Vertosols, Chromosols and Sodosols) supports Alluvial-Plain Shrubland, Riverine Grassy Chenopod Woodland and Riverine Grassy Forest ecosystems (DEPI, 2015).

2.3 Merbein Common

Merbein Common is situated on the Murray River floodplain, 15 km north west of Mildura at Merbein. Merbein Common features two large lagoon systems and an extensive higher elevation area of Black Box woodland and chenopod shrubland.

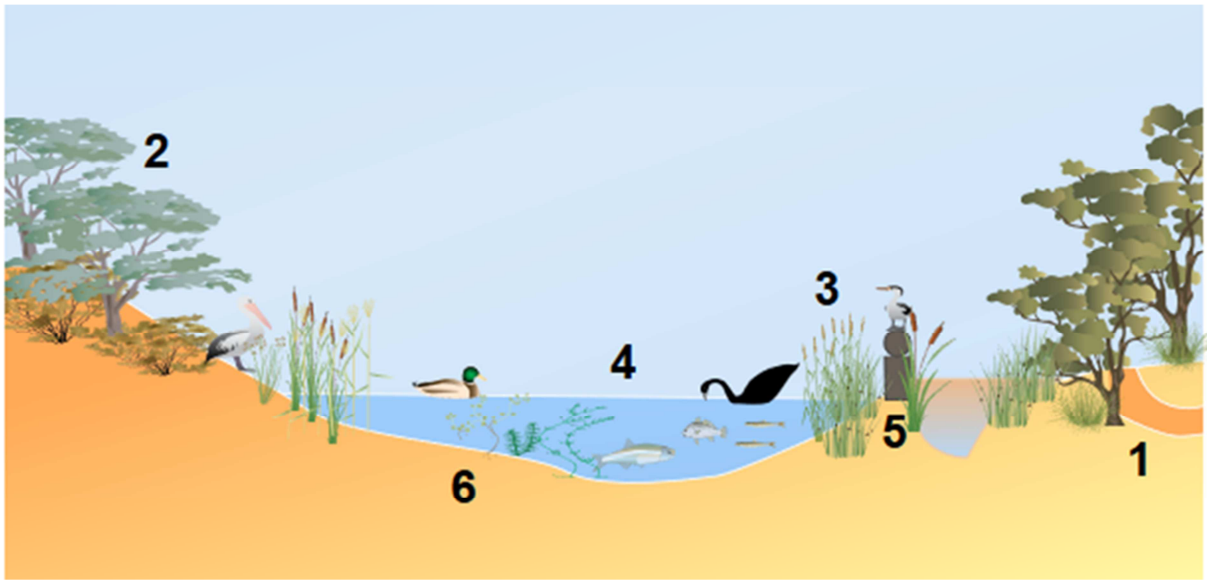
Two wetlands within the system, Cowanna Billabong and Brickworks Billabong have been disconnected from the Murray River by a large bank which historically allowed Brickworks Billabong to be used as an irrigation drainage disposal basin. Cowanna Billabong is a freshwater lagoon and Brickworks Billabong is highly salinised with salinity reaching up to 50,000 EC. Cowanna and Brickworks billabongs are regulated and are now managed for environmental outcomes. A third wetland in the Merbein Common floodplain is Catfish Billabong which is currently inundated by the Lock 10 – Wentworth Weir at the normal operating level of 30.8m AHD. Catfish Billabong transitions from a freshwater wetland near it's connection to the Murray River to a more salinised environment further into the floodplain.

Merbein Common is located within the Murray River Reserve and is popular for activities including walking, bird watching and fishing. Merbein Common has significant Indigenous and European cultural heritage values.

2.4 Conceptualisation of the site

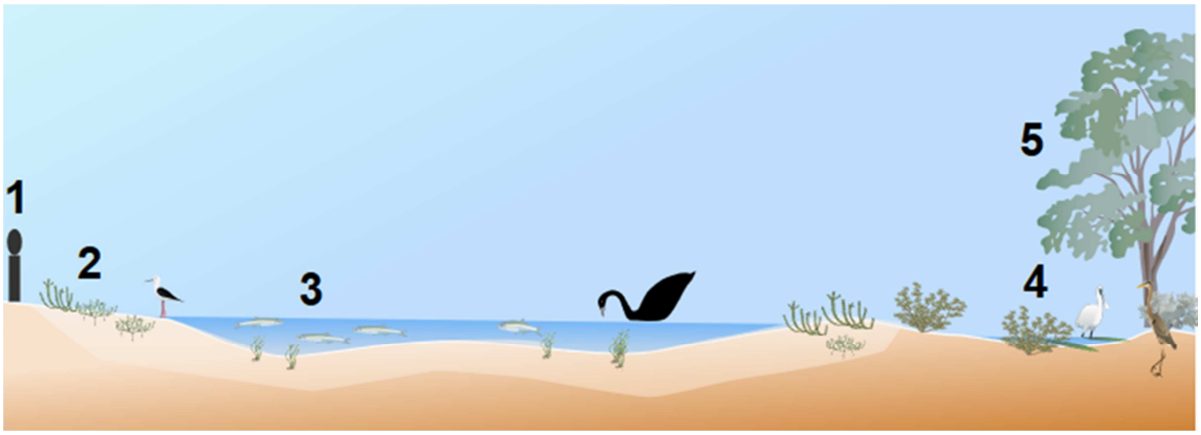
Merbein Common is represented in two conceptual models presented below for Cowanna and Brickworks Billabongs. Catfish Billabong contains ecological and hydrological features found in both Cowanna and Brickworks Billabongs, and is not represented in a separate model. These are visual representations of the processes and components within the target area that are discussed throughout this EWMP.

Cowanna Billabong



1. Merbein Common falls within the Murray River Park and is a popular area used by local residents and visitors for recreation and nature appreciation. Significant walking tracks exist within the area.
   Cultural heritage values are extremely high within the area, and a cultural heritage track skirts Cowanna Billabong.
2. The floodplain consists of two large lagoon systems and an extensive higher elevation area of Black Box woodland and chenopod shrubland.
3. Cowanna Billabong is a linear feature, 16 ha in size, 150 metres wide and extending for one kilometre. It provides permanent open water with depths reaching 2.5 to 3 metres when full. Cowanna Billabong's edges support a narrow patchy fringe of Cumbungi and Phragmites, with shallower edges supporting Juncus species. Water levels should be varied over summer to discourage Phragmites expansion. Healthy River Red Gum are present on the lagoon bank.
4. Cowanna Billabong is able to periodically support a high diversity of small and large bodied native fish. It is also supports good numbers of piscivorous waterbirds, diving ducks and deep-water foragers due to its significant open water habitat.
5. A regulator has been installed at Cowanna Billabong and one is planned for Catfish Billabong.
   The installation of a regulator at Cowanna Billabong allows the raising and drawing down of the water level to increase macrophyte beds, productivity and nutrient cycling, providing habitat for wader birds and food sources such as frogs, small fish and snails.
6. Complete drying out of Cowanna and refilling through a Carp screen has greatly reduced Carp numbers in the billabong and the resulting clear water supports areas of submerged macrophytes.

Brickworks Billabong



1. Brickworks Billabong is isolated from Cowanna Billabong with a levee and regulator, to enable the historic use of Brickworks Billabong as an irrigation drainage disposal basin. There is evidence of salinisation since and Brickworks Billabong is now managed as a permanent saline wetland.
2. Brickworks Billabong is similar in size to Cowanna Billabong and has recorded salinities of between 4,000 and 50,000 EC. The principal salt influx is through saline groundwater interception. Brickworks Billabong has areas of open water or bare mud with halophytic vegetation on the intermittently flooded fringes. Small wading birds have been observed in these areas.
3. Translocation of a population of Murray Hardyhead into Brickworks Billabong has been successful, with breeding observed in the first year. Significant areas of Ruppia species are a key habitat requirement for Murray Hardyhead and are available at Brickworks Billabong.
4. Areas of inundated Intermittent Swampy Woodland support large waders, and would provide habitat for small-bodied native fish.
5. The central floodplain area supports Black Box woodland and Lignum shrubland, which extend into the Blackbox Track Lagoons.

Graphics developed using software provided by the Integration and Application Network, University of Maryland Centre for Environmental Science (ian.umces.edu/symbols/).

2.5 Land status and management

Several agencies and individuals are involved in managing the land and water at Merbein Common (Table 1).

Merbein Common is subject to two public land classifications. It falls within areas of the Murray River Park and Murray River Reserve. Parks Victoria is the land manager at Merbein Common. Land management boundaries are shown in Figure 2.

Table 1 - Stakeholders for the Merbein Common EWMP

Group	Role
Parks Victoria	Land Manager
Mallee CMA	Regional waterway and environmental management
Department of Environment, Land, Water and Planning (DELWP)	State level environmental management planning, land manager, threatened species manager
Victorian Environmental Water Holder	Manager of Victoria's environmental water entitlements
Nyeri Nyeri and Latji Latji community	Indigenous representation
Friends of Merbein Common	Assistance in planning and implementation of programs

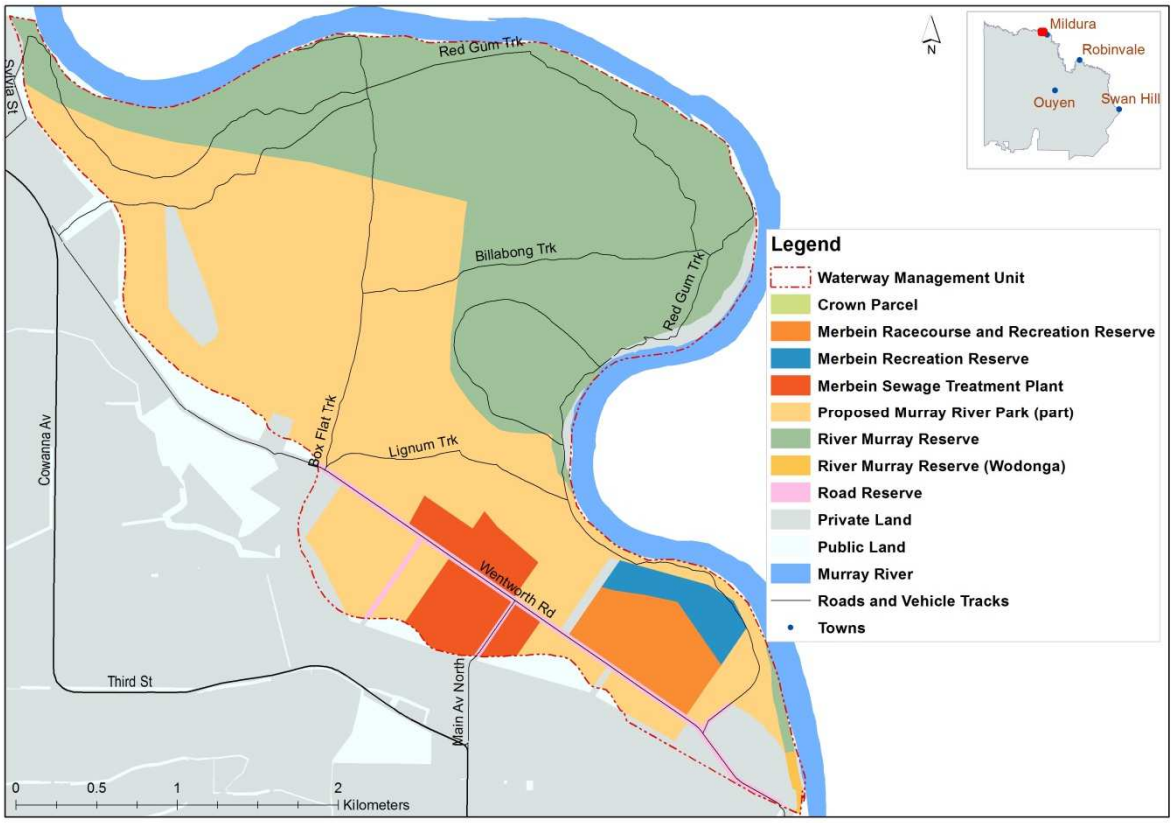


Figure 2 - Land management boundaries within Merbein Common

2.6 Wetland characteristics

A brief overview of the main characteristics of the wetlands at Merbein Common is provided in Table 2. Wetland types found with the Merbein Common are shown in Figure 3.

Table 2 - Wetland characteristics at Merbein Common

Characteristics	Description
Name	Merbein Common
Mapping ID (Wetland Current layer)	Catfish/Horseshoe Bend Billabong: 11443 Cowanna Billabong: 11439 Brickworks Billabong: 11440 Blackbox Track Lagoons A,B,C: 11444 Unnamed: 11441 Unnamed: 11442 Unnamed: 11445 Unnamed: 11515
Area of wetlands in target area	55.28 ha
Bioregion	Murray Scroll Belt
Conservation status	Bioregion conservation status: areas of EVCs listed as Vulnerable, Depleted, and Least Concern
Land status	River Murray Reserve Proposed Murray River Park Crown Land (reserved) Freehold (private) Land
Land manager	Parks Victoria, DELWP, private
Surrounding land use	Dryland cropping, Merbein Irrigation District, township of Merbein
Water supply	Natural inflows from the Murray River and local catchment runoff and salt interception
Wetland category (Wetland Current layer)	Catfish/Horseshoe Bend Billabong: Unknown Cowanna Billabong: Permanent Freshwater Lakes Brickworks Billabong: Unknown Blackbox Track Lagoons A,B,C: Unknown Unnamed # 11441: Temporary Freshwater Swamps Unnamed # 11442: Unknown Unnamed # 11445: Unknown Unnamed # 11515: Unknown
Wetland depth at capacity	Catfish Billabong: 2.3 – 3m Cowanna Billabong: 2.5 – 3m Brickworks Billabong: 2.5 – 3m

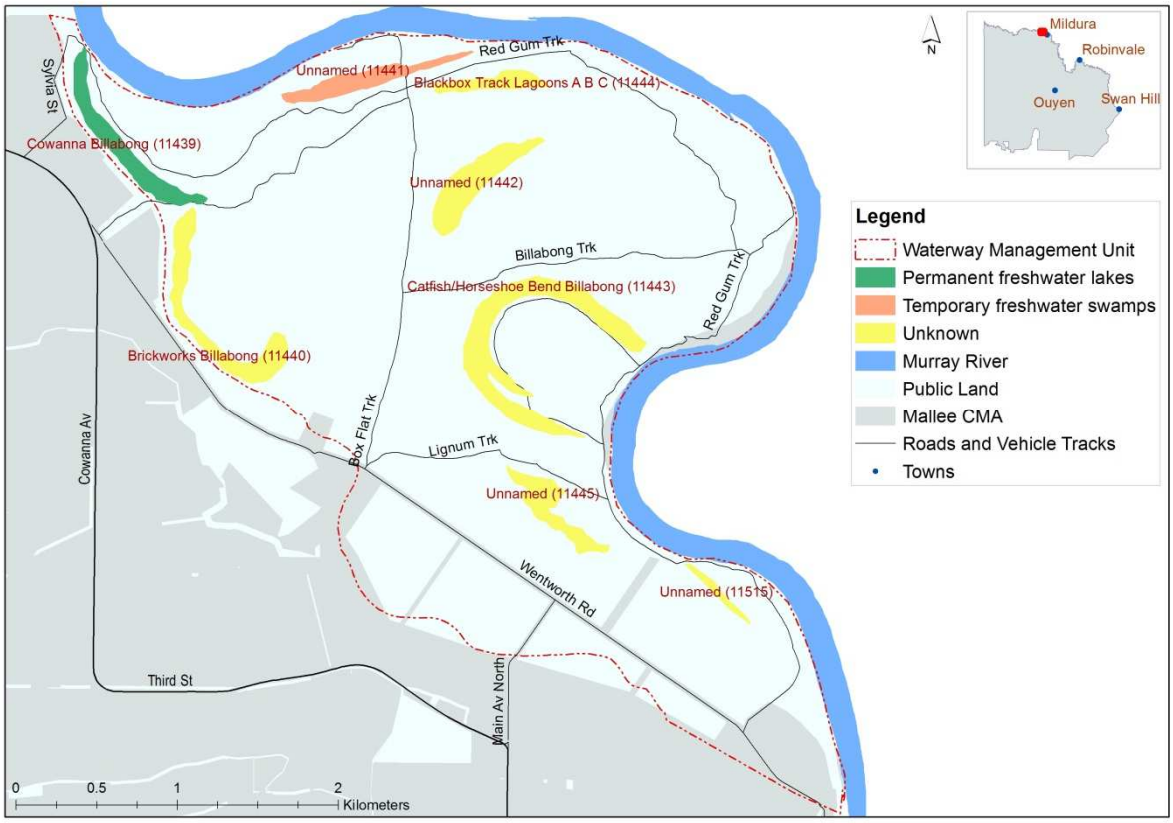


Figure 3 - Wetland types at Merbein Common

2.7 Management scale

The whole of Merbein Common has a water requirement as a floodplain complex, but the focus of this plan is restricted to a target area of 138.9 ha, as shown as the maximum inundation extent in Figure 4.

This target area, consisting of Cowanna Billabong, Brickworks Billabong and Catfish Billabong, is the area of Merbein Common that is able to be managed with environmental water, using existing infrastructure and following the construction of infrastructure proposed in this EWMP.

Expansion of the target area is possible only with significant alterations to Murray River operations such as large releases from storage. This is beyond the scope of this plan but is being addressed at the Murray-Darling Basin scale.

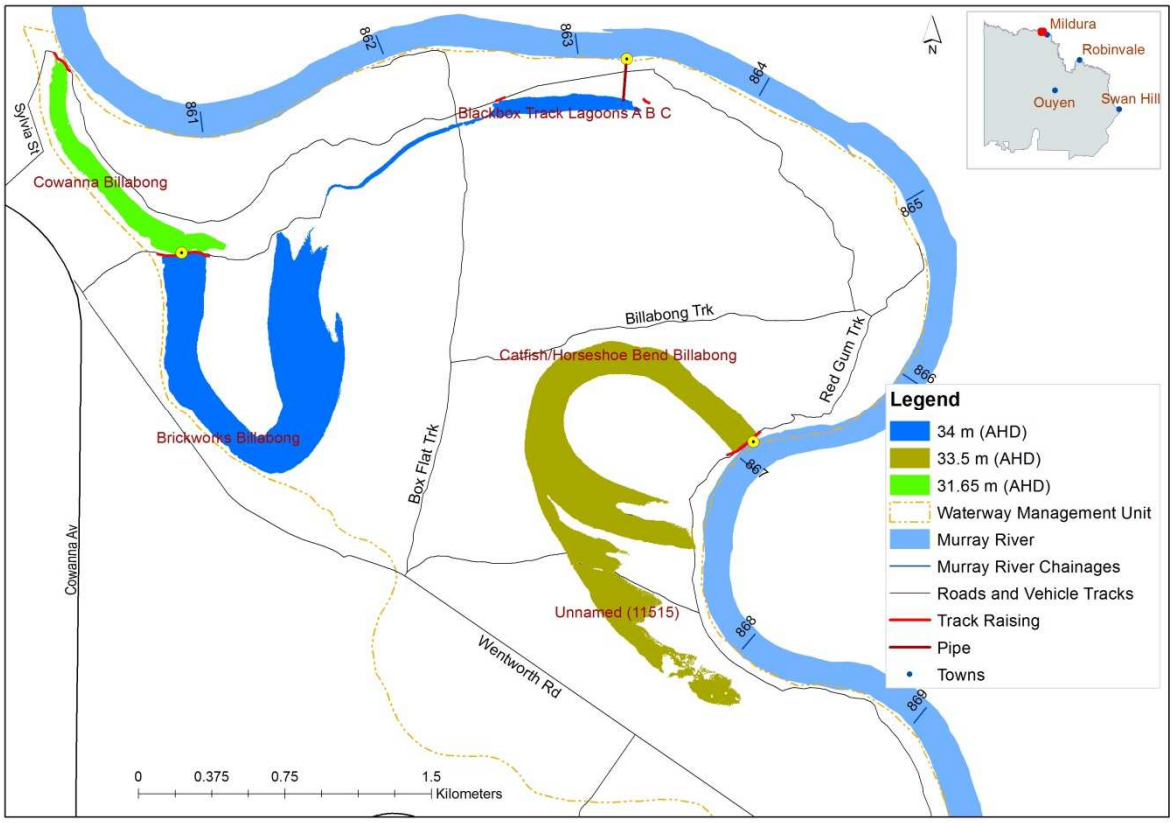


Figure 4 - Target area for the Merbein Common EWMP consisting of the areas shown in the maximum inundation extent.

2.8 Environmental water sources

The Environmental Water Reserve (EWR) is the legally recognised amount of water set aside to meet environmental needs. The Reserve 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, Climate Change and Water appointed Commissioners to Victoria's first independent body for holding and managing environmental water on 1 July 2011 – The Victorian Environmental Water Holder (VEWH) is responsible for holding and managing Victoria's environmental water entitlements, and making decisions on their use.

Environmental water for the target area may be sourced from the water entitlements and their responsible agencies listed in Table 3 and further explained in the Regional Context Document (North, 2014). Previous environmental watering at Merbein Common is outlined in the Environmental Watering section of this EWMP.

Table 3 - Summary of environmental water sources available to Merbein Common

Water entitlement	Responsible agency
Murray River unregulated flows	Murray-Darling Basin Authority
Murray River surplus flows	
Victorian Murray River Flora and Fauna Bulk Entitlement	Victorian Environmental Water Holder
Commonwealth water	Commonwealth Environmental Water Holder
Donated water	Victorian Environmental Water Holder

2.9 Related agreements, policy, plans and activities

There is a range of international treaties, conventions and initiatives, as well as National and State Acts, policies and strategies that direct management of the target area. Those with particular relevance to the site and the management of its environmental and cultural values are listed in Table 4. For the functions and major elements of each refer to the Regional Context Document (North, 2014).

Table 4 - 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) Republic of Korea- Australia Migratory Bird Agreement (ROKAMBA) Convention on the Conservation of Migratory Species of Wild Animals (Bonn Convention)
State	Flora and Fauna Guarantee Act 1988 (FFG)
	DELWP Advisory Lists of Rare or Threatened Flora and Threatened Fauna (VROT advisory lists)

The Merbein Common EWMP was first drafted in 2012. This document is a full revision of the 2012 EWMP.

The Mallee Waterway Strategy (2014) identifies Cowanna Billabong and Blackbox Track Lagoons as high priority wetlands in the Mallee CMA region. Brickworks Billabong and Catfish Billabong are medium priority wetlands in the Mallee Waterway Strategy. Additionally, the Strategy identifies a number of specific management activities for Merbein Common. These activities are:

- Manage regulators and pumping events to avoid European Carp spawning events and benefit native fish (B1.1)
- Install European Carp movements barrier on the Cowanna Billabong regulator (B1.2) – Action is complete
- Maintain a Murray Hardyhead population at Brickworks Billabong (B2.1)
- Manage access to Cowanna Bend to reduce erosion (B3.1)
- Install regulators at Cowanna Billabong and Catfish Billabong to reinstate more natural flow regime (C1.1) - Cowanna action complete
- Modify regulator at Brickworks Billabong (C1.2)
- Deliver water as per EWMPs (C1.3)
- Review EWMP for Merbein Common (F1.1)
- Investigate the feasibility of re-establishing Murray Hardyhead populations at other wetlands within the WMU (F1.5)

The activities identified in the Mallee Waterway Strategy have been considered in the development of this EWMP.

Merbein Common is a priority site for regional investment under the Regional Riparian Action Plan.

A number of earlier investigations into the Murray River floodplain are relevant to Merbein Common and have been considered in the development of this EWMP. These include salinity management plans, flow studies, the Merbein to South Australian Border Frontage Action Project and an investigation into River Red Gum health by the Victorian Environmental Assessment Council (VEAC, 2008b).

Additionally, a number of specific studies have been undertaken at Merbein Common. A recent concept design report – Environmental Watering Infrastructure (SMEC, 2015) presented a concept and detailed design for a regulator upgrade at Brickworks and levees to allow water to be pumped into and maintained on the adjacent floodplain.

Merbein Common was also one of the areas included in the Investigation of Water Management Options for the Murray River – Robinvale to Walpolla (Ecological Associates, 2007b).

DELWP, Parks Victoria and the Mallee CMA have invested significant resources into the area in recent years in both environmental watering and complementary on ground works such as track upgrading, pest plant and animal control, boat ramp upgrades and improved signage to decrease recreational pressures on the floodplain. Management of four-wheel drive access continues to be a challenge for land managers.

Game hunting is a legal activity at Merbein Common.

3 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. A wetland's hydrology is determined by the physical form of the wetland, surface and groundwater inflows and outflows in addition to precipitation and evapotranspiration. Duration, frequency and seasonality (timing) are the main components of the hydrological regime for wetlands and rivers.

Since there are no major tributaries or losses from the Murray River between Robinvale to Wallpolla Island, Ecological Associates (2007) suggest that the hydrology at Merbein Common is best described using gauge #414203 (Murray River @ downstream of Euston Weir).

3.1 Wetland hydrology, water management and delivery

Surface water hydrology

Prior to river regulation in this reach of the Murray River, the floodplain experienced inundation more frequently and for longer periods.

The regulation and diversion of the Murray River has reduced the frequency and duration of peaks in river flow which activate anabranches, fill wetlands and inundate floodplain areas.

Mean annual flows at Euston have been reduced by 49 per cent from natural levels, although seasonality of mean monthly flows is largely unaltered (Maheshwari, Walker and McMahon, 1993; Ecological Associates, 2006) as shown in Figure 5.

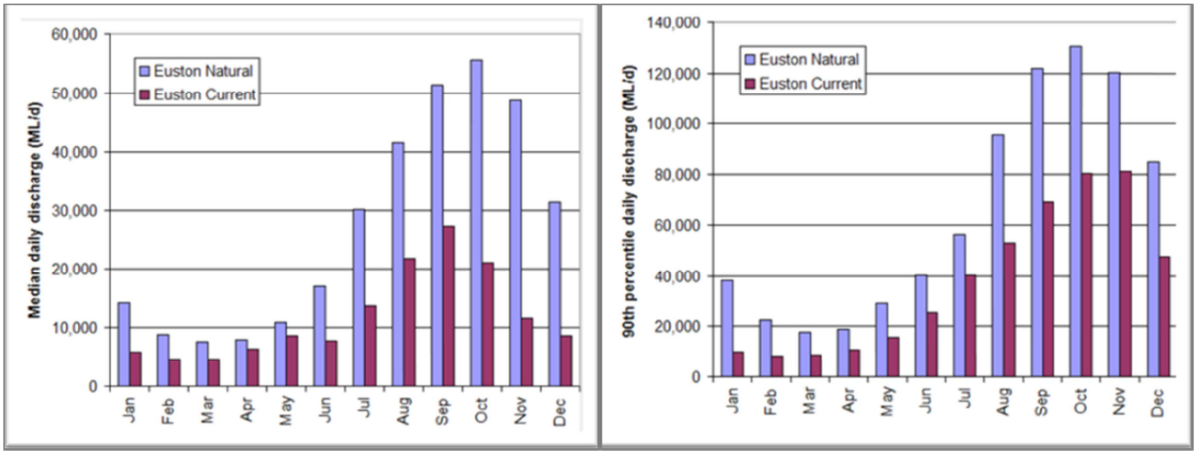


Figure 5 - Distribution of median flows and 90th per centile flows for each month in the Murray River through Euston Weir for pre-regulated and regulated (current) conditions (Ecological Associates, 2006).

In this part of the Murray River, the frequency, duration and magnitude of all but the largest floods have been reduced due to effects of major storages in the Murray and its tributaries (Thoms et al., 2000).

Under pre-regulation conditions the Cowanna and Brickworks Billabong system and Catfish Billabong would have been inundated at approximately 8,000 – 10,000 ML/day.

Under pre-regulation conditions the wetlands would have been inundated on average 93 times per 100 years compared with 135 times per 100 years post-regulation as a result of permanent inundation by Wentworth Weir operations. The median duration of inundation events has been reduced from 243 days to 93 days since river regulation.

Cowanna Billabong

Cowanna Billabong was previously connected to the Murray River by a 600mm inlet pipe, which was located just below the normal river level (30.8m AHD), resulting in the water level within Cowanna rising and falling in conjunction with seasonal fluctuations and operational levels of the Wentworth Weir (Lock 10). The connection pipe between Cowanna Billabong and the Murray River has recently been replaced with a regulator and carp screen to allow a more appropriate watering regime to be managed. Historically, irrigators pumped directly from Cowanna Billabong.

Brickworks Billabong

Brickworks Billabong was isolated from Cowanna Billabong by a block bank/raised road (top of the bank is at 32.3m AHD) so that it could be used as an irrigation drainage disposal basin. A single 450mm pipe provides flow through the bank. Flow between Cowanna and Brickworks Billabong currently commences when river levels are in the order of 20,000 ML/day. Prior to the construction of the causeway, the two wetlands were connected at lower flows. A second blockbank at the far south-eastern end isolates the Billabong from the rest of the floodplain.

Brickworks Billabong is also approximately 150 metres wide and 1 km long and becomes progressively shallower along its length, with a maximum depth of approximately 2.5 metres. The scroll swale which forms Brickworks Billabong continues north-east and diverges into a number of flow paths. The flow paths fill a number of small wetlands known as the Blackbox Track Lagoons before reaching Brickworks Billabong and Cowanna Billabong.

Catfish Billabong

Catfish Billabong is approximately 1.5 km long and 150 metres wide. It is deepest near its connection to the river and becomes progressively shallower as it curves to the south. The wetland has a channel at 867 river km that provides an intermittent connection to the river during low river flows. The connection is located at a broad notch in the river bank, approximately 100 metres wide, 5 metres below the top of the river bank. The connection is formed by a channel in the bed of the wetland, approximately 2 metres deep and 10 metres wide. The channel passes water to the billabong and is unregulated and water returns to the river as flow decreases. The first 800 metres of the wetland is permanently inundated by shallow water (<0.5 metres). During very high flows water reaches Catfish Billabong from an upstream connection.

Groundwater and salinity interactions

Cowanna and Brickworks Billabongs receive saline inflows from two sources: groundwater discharge through the Parilla Sands Aquifer, and natural drainage from the Yelta Irrigation District (Hydro Technology, 1994) (although irrigation drainage has been greatly reduced in recent years).

The elevation of the Parilla Sands aquifer immediately south of the billabongs is approximately 32m AHD (there is little seasonal variation). Salinity in the Parilla Sands aquifer is approximately 2,000 EC. The beds of both Cowanna and Brickworks Billabongs are likely to be in contact with the Parilla Sands aquifer. It is estimated that the Parilla Sands aquifer would contribute approximately 2.7 t/month of salt to each of the billabongs (Hydro Technology, 1994).

Inputs of salt to the Cowanna and Brickworks Billabongs from the Yelta Irrigation District during the 1990's was estimated to be approximately 26.4 t/month and 105.6 t/month respectively (Hydro Technology, 1994).

The isolation of Cowanna and Brickworks Billabong from the Murray River in the 1970's gradually increased the salinity. Salinity levels eventually reached a point where irrigators had to source water directly from the river. Salinity levels in 1987 reached 76,000 EC.

Salt is flushed from the billabongs at flows above 120,000 ML/day. With flows of 20,000 – 30,000 ML/day Cowanna is totally flushed, but Brickworks Billabong is only partially flushed (Hydro Technology, 1994).

Environmental watering

Environmental watering has been provided at Merbein Common in 2005, 2006, 2010, 2013, 2015 and 2016; details are presented in Table 5. Initially, the water was pumped onto the floodplain using temporary earth banks and mobile pumps. However, the installation of a regulator at Cowanna Billabong means that water is able to fill Cowanna Billabong to the Lock 10 level by opening the regulator. Pumping is required to surcharge the wetland. Additionally, pumping has been used to fill Brickworks Billabong, when Cowanna Billabong was subject to a drying phase, via an overland flow channel via the Blackbox Track Lagoons.

Table 5 - A summary of environmental watering at Merbein Common

Water year	Time of inflow	Environmental Water Source	Source volume (ML)	Total volume (ML)	Area (ha) inundated
2005	Spring	Victorian river Murray Flora and Fauna Bulk Entitlement	249 ML	249 ML	46 ha
2006	Autumn		274 ML	274 ML	46 ha
2010	Autumn		445.7 ML	445.7 ML	41.52 ha
2010	Spring		99.96 ML	99.96 ML	67.42 ha
2013	August	VEWH and CEWH	100 ML	100 ML	Brickworks Billabong
2014	June		348 ML	348 ML	Brickworks Billabong
2014/2015	August		400 ML	400 ML	Brickworks Billabong
2015/2016	Sept-Oct[1]		450 ML	450 ML	Cowanna Billabong
	Aug-Sept and Nov-Dec		200 ML	200 ML	23 ha - Brickworks Billabong

Initial environmental watering, undertaken between 2005 and 2010 was an ‘emergency response’ to assist the vegetation during the prolonged dry conditions which had resulted in a decline in River Red Gum health on the Murray River floodplain. Anecdotal evidence suggested that the watering was effective in improving the health of trees (through increased foliage vigour) lining the channels and wetlands in the target area, and had the added benefit of providing drought refuge for waterbirds.

[1] A drying event to meet ecological objectives and Carp control preceded this watering event.

Once the trees began to respond positively to the environmental watering and the dry conditions abated, the purpose of the environmental watering changed from emergency response to ensuring the long term sustainability of key environmental values.

A drying event was undertaken at Cowanna Billabong in late 2015, following the construction of the regulator. The drying event had multiple ecological objectives; however a significant outcome was the control of Carp. Prior to the drying event there was a significant biomass of Carp.

The 2015/2016 watering aimed to maintain and improve the health of River Red Gum communities on the floodplain and improve aquatic vegetation diversity within the wetland. The regulator at Cowanna was opened, to refill the wetland to Wentworth Weir (Lock 10) pool height and then environmental water was used to surcharge Cowanna above weir pool height.

Watering of Brickworks Billabong has targeted the re-introduced population of Murray Hardyhead. The watering has involved an initial filling of the wetland, followed by top-ups as required over the summer months. Brickworks Billabong is generally filled by pumping from Cowanna Billabong. If Cowanna is surcharged it can be used to deliver inflow to Brickworks Billabong, however, this can impact on the duration of inundation for Cowanna Billabong.

During the drying event at Cowanna Billabong, watering of Brickworks Billabong was undertaken via an overland flow path passing through Blackbox Track Lagoons. The use of this flow path enabled the watering of significant areas of Blackbox and Lignum.

Recent vegetation mapping at Cowanna Billabong (Mallee CMA, Unpublished data, 2016) shows a significant increase in submerged macrophytes as a result of the environmental watering regime and the removal of Carp through a drying phase and screens.

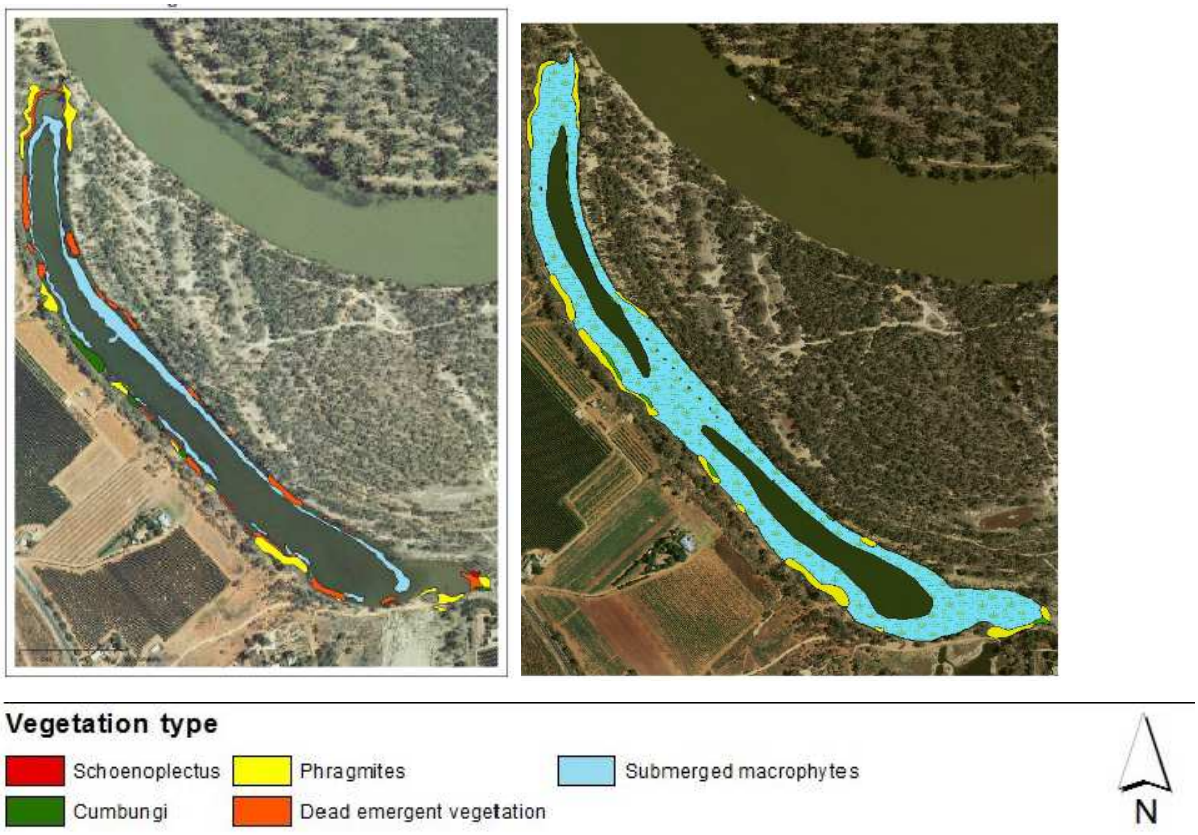


Figure 6 - Comparison of vegetation mapping results at Cowanna Billabong ((Huntley, Ellis and Wood, 2014) and (Mallee CMA, Unpublished data 2016))

4 Water dependent values

Wetlands and waterways on the floodplain are a vital component of the landscape and support flora and fauna which vary with the type of wetland/waterway system. 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.

Merbein Common provides a range of shelter and food resources for indigenous fauna, flora and vegetation communities. The types of habitat provided, and consequently the species that utilise the site, change as water fills the wetlands, creek and floodplain and recedes again.

Data from the Victorian Biodiversity Atlas (DELWP, 2016b) and previous site investigations (Ecological Associates, 2007b) have been referenced. It is recommended that flora and fauna surveys are repeated at the site to improve knowledge of the site's ecological values.

4.1 Environmental values

Listings and significance

Fauna

One hundred and ninety six fauna species have been recorded at Merbein Common, 11 of which are introduced. Of special interest and management responsibility are the 29 water dependent fauna species listed in legislation, agreements or conventions.

Merbein Common supports species listed under the international agreements CAMBA, JAMBA, ROKAMBA and the Bonn Convention; the Commonwealth EPBC Act, Victoria's FFG Act, and the Advisory List of Threatened Fauna in Victoria (Table 3).

These records are drawn from incidental and targeted surveys, including three recent surveys, however it is fair to assume that more listed species are likely to occur due to the availability of habitat and nearby sightings.

Table 6 - Listed water-dependent fauna at Merbein Common

Common name	Scientific name	Type	International agreements	EPBC threatened fauna status	FFG status	VROT advisory list status
Common Sandpiper	*Actitis hypoleucos*	B	Bonn, CAMBA, JAMBA, ROKAMBA	-	-	Vulnerable
Australasian Shoveler	*Anas rhynchotis*	B	-	-	-	Vulnerable
Intermediate Egret	*Ardea intermedia*	B	-	-	Listed	Endangered
Eastern Great Egret	*Ardea modesta*	B	-	-	Listed	Vulnerable
Hardhead	*Aythya australis*	B	-	-	-	Vulnerable
Musk Duck	*Biziura lobata*	B	-	-	-	Vulnerable
Curlew Sandpiper	*Calidris ferruginea*	B	Bonn, CAMBA, JAMBA, ROKAMBA	Critically Endangered		Endangered
Whiskered Tern	*Chlidonias hybrida*	B	-	-	-	Near Threatened
Brown Treecreeper* (south-eastern ssp.)	*Climacteris picumnus victoriae*	B	-	-	-	Near threatened
Murray Hardyhead	*Craterocephalus fluviatilis*	F	-	Endangered	Listed	Critically endangered
Little Egret	*Egretta garzetta nigripes*	B	-	-	Listed	Endangered
Murray Short-necked Turtle	*Emydura macquarii*	R	-	-	-	Vulnerable
Brolga	*Grus rubicunda*	B	-	-	Listed	Vulnerable
White-bellied Sea-Eagle	*Haliaeetus leucogaster*	B	-	-	Listed	Vulnerable
Caspian Tern	*Hydroprogne caspia*	B	JAMBA	-	Listed	Near threatened
Black-tailed Godwit	*Limosa limosa*	B	Bonn, CAMBA, JAMBA, ROKAMBA	-	-	Vulnerable

Common name	Scientific name	Type	International agreements	EPBC threatened fauna status	FFG status	VROT advisory list status
Broad-shelled Turtle	*Macrochelodina expansa*	R	-	-	Listed	Endangered
Golden Perch	*Macquaria ambigua*	F	-	-	-	Near Threatened
Murray-Darling Rainbow Fish	*Melanotaenia fluviatilis*	F	-	-	Listed	Vulnerable
Carpet Python*	*Morelia spilota metcalfei*	R	-	-	Listed	Endangered
Blue-billed Duck	*Oxyura australis*	B	-	-	Listed	Endangered
Pied Cormorant	*Phalacrocorax varius*	B	-	-	-	Near threatened
Royal Spoonbill	*Platalea regia*	B	-	-	-	Near threatened
Glossy Ibis	*Plegadis falcinellus*	B	Bonn	-	-	Near threatened
Pacific Golden Plover	*Pluvialis fulva*	B	Bonn, CAMBA, JAMBA, ROKAMBA	-	-	Vulnerable
Freckled Duck	*Stictonetta naevosa*	B	-	-	Listed	Endangered
Wood Sandpiper	*Tringa glareola*	B	Bonn, CAMBA, JAMBA, ROKAMBA	-	-	Vulnerable
Common Greenshank	*Tringa nebularia*	B	Bonn, CAMBA, JAMBA, ROKAMBA	-	-	Vulnerable
Marsh Sandpiper	*Tringa stagnatilis*	B	Bonn, CAMBA, JAMBA, ROKAMBA	-	-	Vulnerable
Growling Grass Frog	*Litoria raniformis*	A	-	Vulnerable	Listed	Endangered

Legend:

Lifeform type: Bird, Fish, Invertebrate, Amphibian

Convention: China-Australia Migratory Bird Agreement (CAMBA); Japan-Australia Migratory Bird Agreement (JAMBA); Republic of Korea Australia Migratory Bird Agreement (ROKAMBA); Convention on the Conservation of Migratory Species of Wild Animals (Bonn Convention)

**indirectly water dependent*

Of the thirty listed species at the site, the Carpet Python (*Morelia spilota metcalfei*) and Brown Tree-creeper (*Climacteris picumnus victoriae*) are considered indirectly water dependent due to habitat requirements (e.g. dependent on nesting hollows in riparian trees). The rest are directly dependent on water due to food, shelter or breeding requirements.

Birds

White-bellied Sea Eagles (*Haliaeetus leucogaster*) nest near water, in tall live or dead trees, forming pairs for life. River Red Gum are commonly used as nest trees. The total Victorian population is thought to consist of only 100 breeding pairs (Emison and Bilney, 1982; DSE, 2003d).

The Hardhead (*Aythya australis*) favours inland wetlands, preferring deep waters, but also frequents shallow and ephemeral wetlands and inundated floodplains (Rogers and Ralph, 2011; Marchant and Higgins, 1990). The Hardhead dives deep to forage and nests in dense vegetation above the water level, whether permanent water or ephemeral deep water (Rogers and Ralph, 2011; Marchant and Higgins, 1990). The Hardhead lives for approximately three to four years in the wild, therefore conditions suitable for breeding should occur every second year to maintain numbers of breeding adults. Breeding is stimulated by flooding and season (Briggs, 1990). Although information on breeding is limited, it is estimated that fledging occurs at two to three months suggesting flooding should last for four to six months. Food resources are more abundant for Hardhead when a flood follows a period of wetland drying, suggesting that inter-flood drying for a few months may increase breeding success of the Hardhead (Rogers and Ralph, 2011). The Hardhead is reported to use all areas mapped as the EVCs Alluvial Plains Semi-arid Grassland and Bare Rock/Ground at Merbein (VEAC, 2008a).

The Freckled Duck (*Stictonetta naevosa*) mainly forages in shallow areas of wetlands (less than 5cm depth), collecting food by filtering sediment and consuming a mix of plants and invertebrates. Though it can filter feed from the surface of deeper water if food is available (Rogers and Ralph, 2011). Breeding season is mainly between June and December, though it can occur whenever there is plentiful food and suitable flood conditions. Nests are primarily constructed in flooded lignum (Marchant and Higgins, 1990). Flooding should be maintained for six months to ensure that food and breeding resources are maintained. A major threat to the species is the loss of suitable habitat, in Victoria, they have been most frequently recorded at Deep Freshwater Marshes, Permanent Open Water and Saline wetlands (Loyn, 1989 cited in DSE, 2000).

The Blue-billed Duck (*Oxyura australis*) is secretive and prefers stable or permanent deep wetlands with dense and abundant vegetation such as rushes, sedges or lignum. The species is herbivorous (leaves and seeds) (Marchant and Higgins, 1990) but opportunistically consumes crustaceans and insects and can dive to three metres depth. Feeding occurs in open water adjacent to vegetation (Rogers and Ralph, 2011). The breeding season is mostly between September and February, though this varies with hydrological conditions and food availability. Breeding occurs in temporary or permanent waterbodies. For breeding to occur in temporary wetlands, an (estimated) minimum of five to six months flooding is required (Rogers and Ralph, 2011). The Blue-billed Duck nests in vegetation over water, preferring vegetation within one metre of the edge of vegetation in deep water (Marchant and Higgins, 1990). Like the Freckled Duck, the main threats to the species are the loss of suitable wetlands and hunting (DSE, 2003a).

Three Egret species recorded at Merbein Common are the Intermediate Egret (*Ardea intermedia)*, the Eastern Great Egret (*Ardea modesta)*, and the Little Egret (*Egretta garzetta nigripes*). Egrets prefer permanent water bodies on floodplains such as billabongs, creeks or pools but will also use the shallow edges of deep lakes, moist grasslands and wetlands (Marchant and Higgins, 1990). Draining of wetlands is the main cause of habitat loss for Egrets in Victoria (DSE, 2001).

Egrets feed mainly on fish but also consume shrimp, crayfish, frogs and insects (Rogers and Ralph, 2011). They forage in shallow water (approximately 30cm depth for the Eastern Great Egret and up to 8cm for the Intermediate Egret) particularly in areas with aquatic vegetation rather than emergent vegetation, on exposed banks or flats, and from the surface of deeper waters (Marchant and Higgins, 1990). Flooding is a strong stimulus for breeding for all three species and increases breeding success (Briggs, 1990). These species prefer to nest in live trees over floodwaters, but do not seem to have specific depth requirements. The ideal flood duration (resulting in water being maintained around nests) for successful breeding is four to six months for the Little Egret and a minimum of six to seven months for the Eastern Great Egret and Intermediate Egret, however peak breeding can occur after twelve months (Rogers and Ralph, 2011). Inter-flood dry periods are also important to ensure the supply of food and nesting resources (such as healthy River Red Gum) during breeding seasons (Rogers and Ralph, 2011). Similarly to the Hardhead, the Intermediate Egret is reported to use all areas mapped as the EVCs Alluvial Plains Semi-arid Grassland and Bare Rock/Ground at Merbein (VEAC, 2008a).

The Royal Spoonbill (*Platalea regia*) uses both permanent and ephemeral waterbodies in inland areas (Marchant and Higgins, 1990) and prefers freshwater wetlands including swamps with semi-aquatic or emergent vegetation such as rushes. It mainly feeds on fish, crustaceans and insects. Foraging occurs in depths of less than 40cm, with a soft substrate, often among aquatic or emergent vegetation. The productivity of several of its food sources is increased when wetlands are inundated following a dry period (Rogers and Ralph, 2011). The Royal Spoonbill nests over water 0.5 – 1.5 metres deep (Marchant and Higgins, 1990); a minimum flood duration of four to five months is required for successful breeding (Rogers and Ralph, 2011).

The Glossy Ibis (*Plegadis falcinellus*) utilises fresh and brackish swamps, irrigated agriculture, tidal flats and mangroves. It forages mostly on aquatic invertebrates and insects (Rogers and Ralph, 2011). Breeding is stimulated by flooding and flood extent (Briggs, 1990; Kingsford and Auld, 2005), and the two month breeding period (Marchant and Higgins, 1990) requires a flood duration of greater than 5 months, with 8 months being ideal (Rogers and Ralph, 2011). Roosting occurs in dead or live trees near the water, 10 – 50cm above the water height. Glossy Ibis have also been known to nest in reed beds (Leslie, 2001).

The Brown Tree-creeper (south-eastern spp.) (*Climacteris picumnus victoriae*) forages for insects on tree trunks and amongst fallen woody debris on the ground. The majority of their diet is comprised of ants, but also includes other insects such as spiders, moths and larvae as well as sap. Hollows in trees (dead or alive) or tree stumps are essential for nest sites (Office of Environment & Heritage, n.d.). Appropriate inundation regimes will support a healthy and productive forest ecosystem and continued supply of habitat resources such as food, hollows and woody debris.

A range of listed shorebird and wader species have been recorded at the site such as the Pacific Golden Plover (*Pluvialis fulva*), Common Sandpiper (*Actitis hypoleucos*), Marsh Sandpiper (*Tringa stagnatilis*), Common Greenshank (*Tringa nebularia*), Wood Sandpiper (*Tringa glareola*), Black-tailed Godwit (*Limosa limosa*), Caspian Tern (*Hydroprogne caspia*), Whiskered Tern (*Chlidonias hybrida*), and Curlew Sandpiper (*Calidris ferruginea)*. Some of these species may have used shallow waters and mud flats at Merbein Common as a stop-over feeding point on an international migration while others may have over-wintered at the site or nearby (BirdLife Australia, n.d.).

Reptiles

Carpet Pythons are indirectly water dependent, as they rely on habitat provided by River Red Gum forests along major watercourses and benefit from the vertebrate prey species that live in productive wetlands and floodplains. Trees and logs with large hollows, or large rock outcrops, plus thick litter or shrub cover close to (within 100m of) riparian zones, are essential to the existence of Carpet Pythons. Black Box woodlands with hollows further away from waterways are often used for hibernation (Robertson and Hurley, 2001; DSE, 2003c).

Major threats to the Carpet Python habitat include the removal of fallen timber for firewood collection, fox predation, timber harvesting, grazing and rabbit warren fumigation (as Carpet Pythons are known to shelter in rabbit warrens) (Robertson and Hurley, 2001).

The Murray Short-necked Turtle (*Emydura macquarii*), is found primarily in rivers, floodplain waterbodies such as backwaters, oxbows, anabranchs and deep, permanent waterholes, preferring those that are deep, clear, permanent and flowing (Young, 2001; Chessman, 2011, 1988). The Murray Short-necked Turtle is omnivorous, consuming algae, diatoms, fungi and macrophytes as well as invertebrates and fish (Chessman, 2011). It nests primarily after rain. Threats include fox predation on nests, extended dry conditions (Chessman, 2011), and illegal gill netting or drum trapping causing drowning (Georges, White and Guarino, 2003). The Broad-shelled Turtle (*Macrochelodina expansa*) is an obligate carnivore, feeding on crustaceans and invertebrates (Chessman, 1983), takes advantage of temporary waterbodies as well as permanent and nests primarily after rain (Chessman, 2011).

Fish

Murray Hardyhead (*Craterocephalus fluviatilis*) is listed as Endangered under the EPBC Act. The re-introduction of Murray Hardyhead into Brickworks Billabong occurred in 2014, with an initial 70 fish, followed by 2,500 fish in 2015 (Ellis and Wood, 2015). Unpublished monitoring results (Mallee CMA, 2016), indicate that the Murray Hardyhead population in Brickworks Billabong has reproduced. Murray Hardyhead have also recently been found in Cowanna Billabong, although the sustainability of the population is Cowanna is unknown due to the freshwater conditions providing suitable habitat for predators. Cowanna supports extensive submerged macrophyte communities and this may act as a refuge and shelter for Hardyhead.

Murray Hardyhead use the edges of lakes, backwaters and wetlands only in the lowland areas of the southern Murray-Darling basin. They prefer clear, slow-moving or still waters with sand or silt substrate. Juveniles use well vegetated fringes of water bodies and the adults are more commonly seen in open deep water habitat with submerged macrophytes (Ellis, 2005). Plant species associated with the Murray Hardyhead include fringing macrophytes such as Typha and Juncus species and submerged macrophytes such as Myriophyllum and Vallesnaria. The salt-tolerant Ruppia is particularly important in saline lakes (Backhouse, Lyon and Cant, 2008) such as Brickworks Billabong. Recently submerged terrestrial vegetation such as areas of chenopod shrubland can provide temporary cover for the species (Ellis et al., 2013). The Murray Hardyhead consumes mostly zooplankton, some aquatic insects and larvae (Lintermans, 2007).

Remnant populations are generally found within saline habitats, though this correlation may be due to the exclusion of competitors within these water bodies to the advantage of the Murray Hardyhead rather than this being their preferred habitat (Wedderburn, Walker and Zampatti, 2007; Ellis and Kavanaugh, 2014). Adult Murray Hardyhead can tolerate high levels of salinity with a LD50 of 132,000 EC (Wedderburn, Walker and Zampatti, 2008) and have been found in wetlands with salinities ranging from approximately 600 to over 90,000 EC (Ellis, Carr and Pyke, 2012; Stoessel, 2012). Different populations are expected to display different sensitivities to salinity, and little is known of the salinity tolerance of eggs and larvae (Ellis and Kavanagh, 2014).

Spawning occurs during spring and summer when the water temperature reaches 23-24^{o}C. The ripening of eggs is a continuous process during the breeding season and females lay a few at a time over a period of about one month (Cadwallader and Backhouse, 1983). A reduction in water depth in shallow wetlands can expose the critical habitat of submerged macrophyte beds and increase inter and intra-specific resource competition (Ellis and Kavanaugh, 2014). Maintaining water levels and the input of fresh water are important for keeping the salinity levels within the tolerable range for eggs and larvae (Ellis, 2005) though little is known about what this range is (Ellis and Kavanaugh, 2014).

Murray Hardyhead have been recorded in water temperatures ranging from to 5-33°C and has been recorded in water with dissolved oxygen concentrations as low as 2.5 mg/L. The species may benefit from low turbidity as it facilitates macrophyte growth and aid visibility for foraging (Ellis, Carr and Pyke, 2012). The species has been recorded in moderately acidic (pH 6.0) to highly alkaline water (pH 10.4) (Ellis and Kavanaugh, 2014).

The abundance of adults declines at the end of the breeding season (January/February), with replacement by the maturing young of the year cohort. This implies the species is largely annual (populations dominated by individuals aged less than one year (0+) and heavily dependent on yearly recruitment (Ellis 2005). Failed spawning and recruitment may therefore result in the rapid local extinction of populations.

Golden Perch (*Macquaria ambigua*) are usually found in warm, turbid and slow flowing waters in lowland rivers, including backwaters, billabongs and anabranches (Treadwell and Hardwick, 2003) (Treadwell and Hardwick, 2003) and have been recorded in Cowanna Billabong. Fallen logs and woody debris are important habitat for the Golden Perch (Rogers and Ralph, 2011). Large, deep waterholes in dryland rivers are important refugia during dry periods (Balcombe and Humphries, 2006), Golden Perch can tolerate salinities up to 50,000 EC but not low dissolved oxygen (King, Humphries and Lake, 2003). Golden Perch undertake significant migration both upstream and downstream in spring; strong recruitment is linked to rising flows in spring, accompanied by rising water temperatures and extended photoperiod. Major flooding enhances spawning success (King, Tonkin and Mahoney, 2009)

Murray-Darling Rainbow Fish (*Melanotaenia fluviatilis*) is a small fish, up to 90mm long through frequently less than 70mm. 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).

Amphibians

The Growling Grass Frog (*Litoria ranformis*) 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 site generally have a large proportion of vegetation that is emergent, submerged and floating (Clemann and Gillespie, 2012). During the winter months 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).

Vegetation communities

Merbein Common is positioned at the eastern end of the Murray Scroll Belt bioregion, close to the boundary with the Murray Mallee bioregion.

Eight Ecological Vegetation Classes (EVCs) are modelled as present within the target area. Table 7 provides a list of these EVCs, along with their bioregional conservation status. Figure 7 displays the spatial arrangement of the EVCs, and Appendix 2 provides detailed descriptions of the EVCs.

Table 7 - Ecological Vegetation Classes modelled as present within the Merbein Common target area

EVC no.	EVC name	Area modelled as present within target area (ha)	Bioregional conservation status
102	Low Chenopod Shrubland	1.89	Depleted
103	Riverine Chenopod Woodland	10.89	Depleted
104	Lignum Swamp	1.43	Vulnerable
806	Alluvial Plains Semi-arid Grassland	53.03	Vulnerable
808	Lignum Shrubland	22.12	Least concern
813	Intermittent Swampy Woodland	10.35	Depleted
818	Shrubby Riverine Woodland	0.92	Least concern
823	Lignum Swampy Woodland	6.36	Depleted

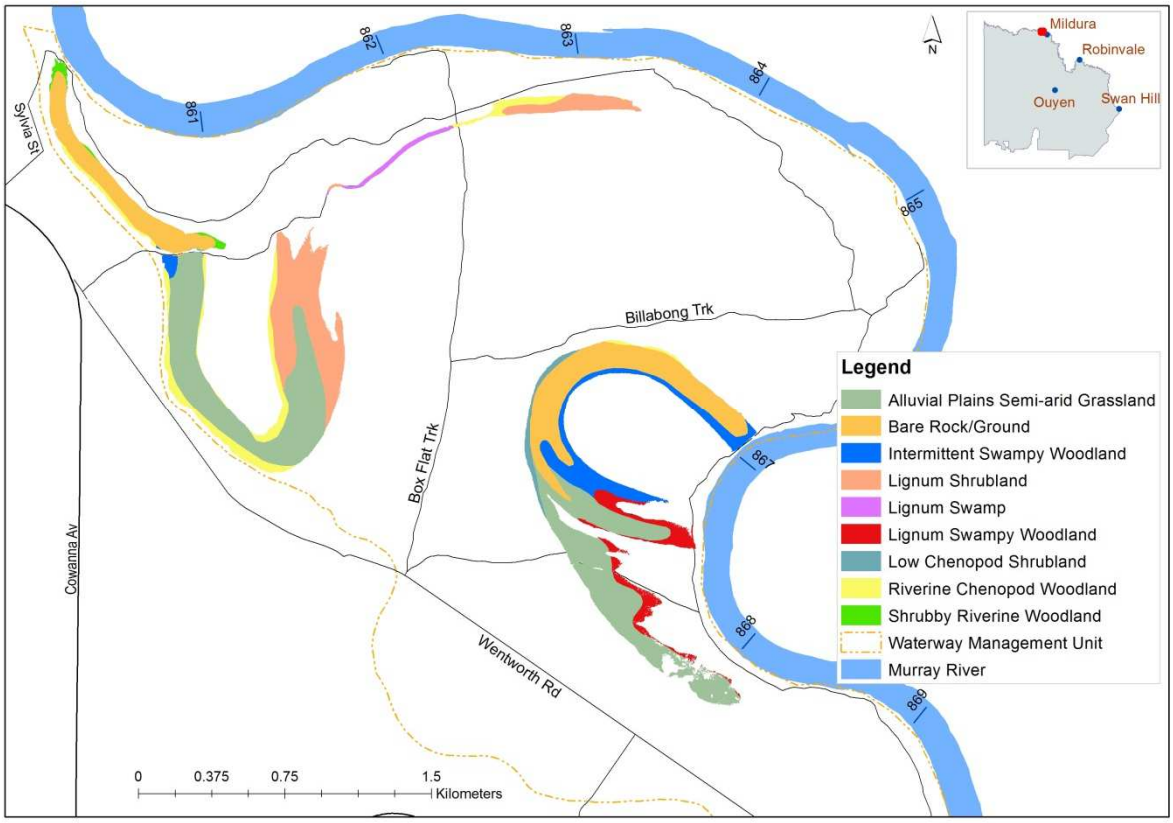


Figure 7 – Ecological Vegetation Classes present in the Merbein Common target area

Alluvial Plains Semi-arid Grassland is modelled as present along the bed of Brickworks Billabong and areas of Catfish Billabong. It is a mix of low grassland and herbland with few shrubs. It is flood-promoted, occupies low-lying areas and is comprised of opportunistic ephemeral or annual species.

Brickworks Billabong is surrounded by halophytic vegetation in the shallow water and surrounding mud flats interspersed with salt-tolerant chenopod shrubs (Figure 8).

Figure 8 - Brickworks Billabong is surrounded by halophytic vegetation.

Cowanna Billabong is almost permanently inundated and surrounded by a narrow band of rushes and healthy River Red Gums (Figure 9).

Figure 9 - Cowanna Billabong is fringed by a narrow band of rushes and surrounded by Riverine Chenopod Woodland and Shrubby Riverine Woodland.

Terraces surrounding both lagoons support Riverine Chenopod Woodland and Shrubby Riverine Woodland. Both are eucalypt woodlands to 15m tall, with Shrubby Riverine Woodland's overstorey dominated by River Red Gum and Black Box, and Riverine Chenopod Woodland only by Black Box.

Healthy River Red Gums provide extensive habitat for a range of fauna, and waterbirds can use these trees for nesting. River Red Gums also deposit organic woody debris to wetlands which provide structural habitat features for wetland fauna such as perching sites for waterbirds and snags for fish (Roberts and Marston, 2011). Ideal flooding for River Red Gum recruitment is late spring to early summer (Johns et al., 2009), while ideal flood timing for River Red Gum maintenance and survival is winter to spring following the natural flooding pattern (Dalton, 1990).

Black Box provides essential habitat and foraging opportunities for a range of species including mammals and reptiles and supports a high proportion of ground foraging and hollow-nesting birds. Black Box can tolerate a range of moisture and salinity conditions (Roberts and Marston, 2011), however recruitment and establishment is linked to the elevated and continued soil moisture associated with flood events. Under extended periods of dry conditions Black Box is likely to decline and eventually die (Ecological Associates, 2007a).

Riverine Chenopod Woodland has a diverse shrubby and grassy understorey and is subject to only extremely infrequent incidental shallow flooding from major events. Riverine Chenopod Woodland is also found in association with Intermittent Swampy Woodland and Lignum Swampy Woodland near Catfish Billabong.

Intermittent Swampy Woodland (Figure 10) has an overstorey of River Red Gums and or Black Box and an understorey of sedges and shrubs, including Lignum. Lignum Swampy Woodland has a similar overstorey but an understorey dominated by lignum and obligate wetland flora. Areas of inundated Intermittent and Lignum Swampy Woodland support large waders, and would provide habitat for small-bodied native fish.

Figure 10 - Intermittent Swampy Woodland next to Catfish Billabong.

As well as the lagoon systems of Cowanna/Brickworks Billabong and Catfish Billabong, the floodplain also supports an extensive area of Black Box woodland and Low Chenopod Shrubland. Close to wetlands and flow paths overstorey trees are healthy or recovering, further away from flow paths trees are in poor health (Figure 11 and Figure 12).

Figure 11 - Close to wetlands and flowpaths, vegetation is recovering.

Figure 12 - Away from wetlands and flow paths, vegetation is declining.

Lignum Shrublands are located in shallow depressions higher on the floodplain, within areas of River Red Gum and Black Box Woodland. Following flood peaks these areas hold water for months, increasing the health and productivity of the Lignum. Lignum can survive several years without inundation (Ecological Associates, 2007b).

Flora

Eighty eight species of flora have been recorded at Merbein Common (a full list of flora can be found in Appendix 3). Of these, 24 are listed under the FFG Act and/or the Advisory List of Rare or Threatened Flora in Victoria (Table 8), and 12 of these are considered inundation dependent as they are found around lakes, waterways or on floodplains and/or propagate more readily with inundation. Fourteen introduced flora species have also been recorded at the site.

Merbein Common is one of only five sites in Victoria known to host the FFG listed Dwarf Lantern-flower (*Abutilon fraseri*). It is a good coloniser after disturbance or fire, threats to the species include human disturbance such as four wheel driving off track and rubbish dumping and isolation from other populations as pollinators can't move long distances (DSE, 2003b).

Submerged macrophytes within the semi-permanent and permanent waterbodies form important aquatic habitat for fish such as the Murray Hardyhead. These species root in the sediment of slow-flowing or still waters and their canopy is almost or entirely underwater. Permanent water may not always favour these species as they may be outcompeted by other aquatic plants and a high abundance of Carp can act to dislodge the roots. Ribbon Weed (*Vallisneria australis*) is tolerant of low light levels and can grow at depths of up to 7 m, though the depth at which it can establish is limited by light penetration and 1 – 2 m is optimal. It can grow in salinities up to one third of seawater, but its capacity to grow and withstand drying is both reduced under these circumstances (Salter, Morris and Boon, 2008). Growth peaks over summer and autumn. It can survive drying periods of up to four months and seeds may remain viable in dry sediments for up to nine years (Rogers and Ralph, 2011; Roberts and Marston, 2011).

Table 8 - Listed flora recorded at Merbein Common

Common name	Scientific name	Inundation dependent	FFG status	VROT advisory list status
Dwarf Lantern-flower	*Abutilon fraseri*	unknown	L	All infraspecific taxa included in Advisory List
Desert Lantern	*Abutilon otocarpum*	no	-	Vulnerable
Nealie Wattle	*Acacia loderi*	no	L	Vulnerable
Yarran	*Acacia melvillei*	no	-	Vulnerable
Bramble Wattle	*Acacia victoriae* subsp. *victoriae*	yes	-	Rare
Common Joyweed	*Alternanthera nodiflora*	yes	-	Poorly known
Tall Kerosene Grass	*Aristida holathera* var. *holathera*	no	-	Vulnerable
Silver Saltbush	*Atriplex rhagodioides*	yes	L	Vulnerable
Blue Burr-daisy	*Calotis cuneifolia*	unknown	-	Rare
Spiny Lignum	*Duma horrida* subsp. *horrida*	yes	-	Rare
Smooth Elachanth	*Elachanthus glaber*	yes	-	Rare
Bristly Love-grass	*Eragrostis setifolia*	yes	-	Vulnerable
Spreading Emu-bush	*Eremophila divaricata* subsp. *divaricata*	yes	-	Rare
Spotted Emu-bush	*Eremophila maculata* subsp. *maculata*	yes	-	Rare
Narrow-leaf Emu-bush	*Eremophila sturtii*	no	L	Endangered
Leafy Sea-heath	*Frankenia foliosa*	no	-	Rare
Bristly Sea-heath	*Frankenia serpyllifolia*	yes	-	Rare
Pearl Bluebush	*Maireana sedifolia*	no	-	Rare

Common name	Scientific name	Inundation dependent	FFG status	VROT advisory list status
Goat Head	*Malacocera tricornis*	yes	-	Rare
Doubah	*Marsdenia australis*	no	-	Vulnerable
Sandhill Spurge	*Phyllanthus lacunellus*	yes	-	Rare
Sarcozona	*Sarcozona praecox*	no	-	Rare
Twiggy Sida	*Sida intricata*	yes	-	Vulnerable
Small-leaf Swainson-pea	*Swainsona microphylla*	no	-	Rare

Other fauna

Waterbirds

Waterbird diversity and abundance are influenced by wetland habitat diversity, with different species and feeding guilds using different habitats for breeding and foraging (Haig, Mehlman and Oring, 1998). Water depth in particular influences waterbird diversity due to the specific feeding behaviours of different species (Bancroft, Gawlick and Rutchey, 2002). Managing wetlands to provide diverse habitats such as variable water depth, mud flats, inundated vegetation and areas of deep water increases the likelihood of increased waterbird diversity (Taft, Colwell, Isola and Safran, 2002).

Recommendations within this EWMP will be directed toward providing the habitat through a watering regime appropriate to providing key habitat needs of the waterbird guilds listed in Table 9. This is based on the habitat types available at the site.

Table 9 - Waterbird functional feeding groups (Roshier, Robertston and Kingsford, 2002) and their resource use.

Waterbird Group	Food Resource	Habitat Use	Waterbird Group
Dabbling and Diving Ducks (e.g. Chestnut teal, Pink-eared duck, Freckled duck)	Generalists; plankton, small invertebrates, plant material	Shallow Water (Dabblers)	Solitary
Grazing Waterfowl (e.g. Shellduck, Wood Duck)	Plant material, seeds, invertebrates	Shallow Water, littoral zone	Colonial or solitary
Fish Eaters (e.g. Pelican, Cormorants, Grebes, Darter, Egret, Heron, Tern)	Fish	Open and deep water	Colonial
Small Waders (e.g. Stilt, Plovers, Dotterels)	Small invertebrates, seeds	Littoral zone, mudflats	Solitary
Large Waders (e.g. Ibis)	Macroinvertebrates, fish, amphibians	Littoral zone	Colonial or solitary
Shoreline Foragers (e.g. Lapwings, Hens)	Plant material, seeds, invertebrates,	Littoral zone, mudflats	Solitary or small groups

Providing appropriate water requirements to support the vegetation communities will support habitat for birds that have adapted to the required flooding and drying cycle (Scott, 1997). With an appropriate water regime waterbirds will utilise areas of shallow water, mudflats and the littoral zone in floodplain channels and wetlands found in the Merbein Common target area (Figure 13 and Figure 14).

Figure 13 - Brickworks Billabong hosts large numbers of Swans, Pelicans and a range of shorebirds.

Figure 14 - The shallow waters and mud flat edges of Catfish Billabong support wader birds.

Fish

A complex and diverse habitat within the wetlands provides an abundance of food and protection from predators. Many native fish species such as Gudgeon species. prefer slow-flowing waters and wetlands vegetated by submerged macrophytes and other riparian cover, including small woody debris(Allen, Midgley and Allen, 2003).

Flathead Gudgeon (*Philypnodon gradiceps*) and Western Carp Gudgeon (*Hypseleotris klunzingeri*) and have been recently recorded at Cowanna Bend. Gudgeon species are wetland opportunists, preferring slow-flowing or still waters with a muddy substrate, woody debris and aquatic vegetation. Their diet includes small crustaceans, aquatic insects, tadpoles and small fish (Lintermans, 2007). Other fish species recently recorded at the site include flood spawners Spangled Perch (*Leiopotherapon unicolor*), wetland specialists Bony Herring (*Nematalosa erebi),* main channel generalists Australian Smelt *(Retropinna semoni)* and low flow and wetland opportunists Unspecked Hardyhead (*Craterocephalus stercusmuscarum fulvus*).

Wetland depletion and rarity

The conservation significance of Victorian wetland types has been determined by comparing the estimated extent prior to European settlement with the remaining extent.

All three wetlands addressed in this EWMP are classified as Permanent Open Freshwater wetlands. The overall decline of this wetland type in Victoria is 6%. In the Mallee CMA this wetland type has actually increased by 5% due to the creation of permanent aquatic habitats through the construction of weirs and irrigation infrastructure. The Murray Scroll Belt bioregion has seen a decline of 7% (Table 10).

Table 10 - Changes in area of the wetlands in the target area by Corrick classification Source: DELWP Biodiversity interactive maps, Mallee Wetland Strategy

Corrick category	Wetland name	Total area (ha)	Percentage change in wetland area from 1788 to 1994		
			Change in Victoria	Change in Mallee CMA	Change in Murray Scroll Belt
Permanent Open Freshwater	Catfish Billabong Brickworks Billabong Cowanna Billabong	27.41 15.25 12.62	-6%	+5%	-7%

Ecosystem functions

Wetland ecosystems support distinctive communities of plants and animals and support numerous ecosystem functions. Floodplain wetlands perform important functions necessary to maintain the hydrological, physical and ecological health of river systems.

Four key broad ecosystem functions have been identified for the Merbein Common EWMP. Each function is interlinked and must be supported in order for the ecosystem to flourish. The functions are briefly described below.

Creation and maintenance of vital habitats and populations

Maintenance of permanent shallow brackish habitat in the Brickworks Billabong will allow the key Murray Hardyhead population to continue to thrive and expand.

Permanent waterbodies act as refugia for frogs such as the Growling Grass Frog, native fish and waterbirds during periods of extended drought in an arid landscape.

Inundation of areas of the wetland woodland mosaic provides a diversity of feeding, breeding and nursery sites for native water-dependent biota including waterbirds.

The mature River Red Gum at this site provide habitat hollows for species such as Carpet Python and a range of bird species. Mature River Red Gum are also an important source of fallen timber habitat for Carpet Python on the floodplain.

Connections across floodplains, adjacent wetlands and billabongs (lateral)

Water levels that engage flood channels, wetlands and floodplain surfaces promote nutrient and carbon cycling and return organic material to the river where it contributes to the riverine food web (Robertston, Bacon and Heagney, 2001a).

Diversity of habitat for feeding, breeding and nursery

Seasonal fluctuations in water levels in the wetlands increase the availability of specific habitat niches for feeding, breeding and nursery areas. Permanent and semi-permanent water bodies provide a source of food, refuge from predators and nesting sites and materials (Kingsford and Norman, 2002). Receding water levels expose the mudflats at Brickworks Billabong and Catfish Billabong required by small waders (Roshier, Robertston and Kingsford, 2002).

Wetland filling and water recession increases the extent of the band of sedges, rushes and semi-

aquatic forbs surrounding wetlands. Areas of deeper, permanent water support submerged aquatic macrophytes, and promote high levels of aquatic productivity and high habitat value for frogs, fish, and waterbirds.

Transportation and dilution of nutrients and organic matter and increase in macroinvertebrate productivity and biofilm diversity

Drying of wetlands, particularly during summer and autumn, exposes sediments and facilitates decomposition and processing of organic matter. The microbial decay of plant material is an important route for energy and nutrients to enter the riverine food chain (Young, 2001).

Wetland inundation transports nutrients and carbon into the water column, which then becomes available for consumption by bacteria, algae and macroinvertebrates. On re-wetting, decomposition accelerates and becomes more efficient. Carbon and nutrients are released from the soil and enter the water and are available for aquatic plants and animals. The release of energy and nutrients results in increased productivity, with an increase in bacteria and invertebrates (Ecological Associates, 2013). This results in abundant food for fish, birds and other animals.

Fluctuations in water levels allows exposure of substrates such as large wood and plant stems through a drying cycle, which increases the diversity of the biofilms grazed by macroinvertebrates and fish.

4.2 Social values

Cultural value

The Mallee region 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 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 densities 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 concentration and diversity. They include large numbers of burials and hunting sites and middens.

In the south of the region, waterways were focal points for the region's traditional owners, with many lakes being the site for large gatherings of several social clan groups that afforded trade and cultural exchanges.

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

Merbein Common holds significant indigenous cultural values and is the site of the oldest shell midden in South Eastern Australia, estimated at 15,500 – 16,000 years old (Parks Victoria, 2014).

The Nyeri Nyeri were the indigenous community at the time of settlement however there are currently no native title claims over the Merbein Common. Currently there is no Registered Aboriginal Party for the area however there is an application before the Victorian Aboriginal Heritage Council for the area by the First People of the Millewa-Mallee Aboriginal Corporation (DPC, 2016).

Sites of post-colonisation historical significance include Chaffey Landing, named for the original owner of the winery/distillery on the cliff on the eastern boundary of Merbein Common. This was an early access point for paddle steamers collecting grape spirit for transport to Adelaide as well as a makeshift settlement during the Great Depression in the 1930s. Dr Wilhelm Blandowski, a nineteenth century botanist used Chaffey Landing as a base for flora collection in the 1850s, eventually collecting 17,000 flora specimens across north west Victoria with the assistance of the Nyeri Nyeri people (Parks Victoria, 2014).

4.3 Recreation

Merbein Common is close to Mildura and its easy accessibility, permanent water, diversity of scenery and access to the Murray helps to make it popular for walking, picnicking (several designated picnic areas and tables are provided), birdwatching, fishing and four wheel driving. Four wheel driving off-track during wet weather has led to significant damage to soils, roads and vegetation. Works are underway to block access to vehicles in some areas. Recreational fish species at the site include Golden Perch, Murray Cod and Yabbies.

A range of walking trails are present at the site, including the Cultural and Nature Trail (Figure 15 and Figure 16) which meanders along the north boundary of Cowanna Billabong and loops back through the Shrubby Riverine Woodland, the Archaeological Trail which circumnavigates Brickworks Billabong, and the Link Trail and Lookout Walk which showcase River Red Gum and Black Box woodlands.

Figure 15 - Entry to the Cultural and Nature Trail; Cowanna Billabong is pictured to the right.

Figure 16 - Cultural and Nature Trail along Cowanna Billabong.

4.4 Economic values

The site is adjacent to the town of Merbein and only 13 kilometres from the rural centre of Mildura. Surrounding land uses include citrus growing, vineyards and wineries and dried fruits. Merbein Common is on the site of the original pump station for the region (Strudwick, 2016).

4.5 Significance

Merbein Common is a significant site for environmental watering due to its close proximity to the township of Merbein, high visitor numbers and profile and its significance as a relocation site for Murray Hardyhead. The three wetlands within the target area offer a significant variety of habitats for waterbirds and both small and large-bodied native fish.

5 Ecological condition and threats

5.1 Current condition

Index of Wetland Condition assessments are not available for the wetlands within Merbein Common.

The condition of Cowanna Billabong appears to be reasonably good since the installation of the regulator and the implementation of a drying period in 2014/2015 prior to environmental watering in 2015/2016. Fish surveys undertaken between 2006 and 2010 found seven species of native fish in the wetland including Spangled Perch (*Leiopotherapon unicolor*), Golden Perch (*Macquaria ambigua*), Flathead Gudgeon (*Philypnodon grandiceps),* Unspecked Hardyhead *(Craterocephalus stercusmuscarum fulvus),* Carp Gugeon *(Hypseleotris klunzingeri),* Australian Smelt *(Retropinna semoni)*and Bony Herring *(Nematalosa erebi).* Gambusia and Carp were also found during the surveys, although no Carp were found in the surveys following the installation of the regulator.

There is some concern from environmental managers that the spread of Cumbungi may affect long term condition. However, it seems that the extent of Cumbungi increased briefly when the wetland dried and has not increased significantly since. A water regime with annual fluctuations as recommended in this plan will assist with maintaining a diverse macrophyte community. The health of terrestrial vegetation surrounding the wetland is good, with healthy River Red Gums and Blackbox Woodlands present immediately abutting the wetland.

Brickworks Billabong is a saline wetland. It was previously a semi-permanent freshwater wetland, however management objectives now focus on maintaining the wetland as a permanent saline wetland capable of maintaining a self-sustaining population of Murray Hardyhead. Recent surveys suggest that this objective is being met with conditions supporting beds of *Ruppia spp.* and evidence of Murray Hardyhead recruitment. Recent fish surveys in Brickworks Billabong have found five species of native fish including Murray Hardyhead (*Craterocephalus fluviatilis*), Un-specked hardyhead (*Cretarocephalus stercusmuscarum fulvus*), Carp Gugeon (*Hyseleotris spp*.), Australian Smelt (*Retropinna semoni*) and Bony Herring (*Nematalosa erebi*), Large numbers of *Gambusia holbrooki* were also found within Brickworks Billabong, and these may compete with Murray Hardyhead for resources.

Significant areas of salt tolerant vegetation surround the wetland and these provide habitat for small wading birds. Large numbers of waterbirds have been seen during recent fieldwork using both Brickworks and Cowanna Billabong, with different assemblages using the different environments.

Catfish Billabong is in reasonably poor condition, with static water levels and high levels of Carp impacting on water quality and vegetation health within the wetland. Ecological Associates (2007) also noted that tree health is in very poor condition in the southern half of the wetland and understorey vegetation is largely absent. The area appears to be affected by significant salination. Catfish Billabong is also reported as being at high risk for the development of acid sulphate soils (Ian Ellis. *pers. comm*, 27/2/2007: cited in Ecological Associates, 2007).

5.2 Condition trajectory

The water management regime within Cowanna Billabong and Brickworks Billabong has already lead to significant improvement in the environmental conditions at these sites. As discussed earlier, there has already been significant improvement in the extent of submerged macrophytes within Cowanna Billabong. Recent studies have also found Murray Hardyhead within Cowanna Billabong, although the sustainability of the population will be subject to investigation.

Catfish Billabong is still subject to extensive impact by the static water levels and European Carp, which are both expected to be remedied following the installation of a suitable regulator with Carp screens at the site.

Brickworks Billabong is now managed as a permanent saline wetland, and must be managed to support the lifecycle requirements of the Murray Hardyhead.

5.3 Water related threats

The Aquatic Value Identification and Risk Assessment (AVIRA) database is an on-line tool used by Victorian waterway managers to store data about the values, threats and risks to waterway health in their region. The database evaluates threats for a range of sub-indices including water regime, invasive fauna and acid sulphate soils (Peters, 2009).

Changed water regime

The hydrology of the target area has been greatly impacted by the regulation of the Murray River. Cowanna and Brickworks Billabongs were identified as having the highest threat level for changed water regime. The hydrology sub-index takes into account the impacts of regulation of the primary water source of the wetland (Murray River), other activities which may impact the wetlands water regime, impacts to seasonality, duration and frequency of the water regime and the severity of the effects of these activities. The assessment is subjective. Catfish Billabong is currently permanently connected to the Murray River as a result of the water levels associated with Lock 10. The construction of regulators at each of the three wetlands will result in improvements to the water regime.

Invasive fauna (aquatic)

Before the wetland was regulated and dried out, Carp were prevalent in Cowanna Billabong. They are still prevalent in Catfish Billabong. Carp have been found to contribute to the loss of aquatic vegetation and increased turbidity, resulting in loss of habitat for waterfowl (Purdey and Loyn, 2008) and native fish species. This species also competes with the native fish for habitat and food (Mallee CMA, 2003).

Gambusia (*Gambusia holbrooki)* directly competes and predate on Murray Hardyhead and other small-bodied native fish.

6 Management objectives

6.1 Management goal

The management goal for the Merbein EWMP is:

"Cowanna Billabong and Catfish Billabong to be permanent wetlands that are intermittently connected to the Murray River that will support a diverse fish and bird community through high levels of aquatic productivity. Brickworks Billabong will be a significant site for the conservation of Murray Hardyhead."

6.2 Ecological objectives

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

The ecological objectives for Merbein Common are:

Cowanna Billabong and Catfish Billabong

- Diverse large and small-bodied native fish community
- Provide productive feeding habitat for large wading birds
- Maintain high levels of aquatic productivity
- Extensive submerged aquatic macrophytes such as *Potomegeton* spp. and emergent macrophyte community
- Diverse fringing emergent macrophyte community over a broad littoral zone

Catfish Billabong

- Inundate Intermittent Swampy Woodland vegetation to provide foraging and resting habitat for large waders

Brickworks Billabong

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

Table 11 - Ecological objectives for Merbein Common

Ecological objective	Justification	Wetland area
Diverse large and small-bodied native fish community	As well as the intrinsic value of native fish presence, small-bodied native fish also provide an important food source for piscivorous waterbirds and some large-bodied native fish species.	Cowanna, Catfish
Provide productive feeding habitat for large wading birds	Six listed species of large waders have previously been found within the target area.	Cowanna, Catfish
Maintain high levels of aquatic productivity	Alternating periods of inundation and exposure accelerate the decomposition of organic matter and increase availability fo organic carbon and mineral nutrients in the wetland food web.	Cowanna, Catfish, Brickworks Billabong
Extensive submerged aquatic macrophytes such as Potomegeton spp. and emergent macrophyte community	Macrophytes provide habitat for a range of species including shelter from predators, nesting sites and a source of organic matter.	Cowanna, Catfish
Diverse fringing emergent macrophyte community over a broad littoral zone	Semi-emergent macrophytes provide highly productive wetland habitats. The soft-leaved plants and their biofilms provide shelter and flood for macroinvertebrates, tadpoles and small fish. Waterfowl and dabbling ducks, will graze on the vegetation and prey on macro-invertebrates (Ecological Associates, 2006).	Cowanna, Catfish
Inundate Intermittent Swampy Woodland vegetation to provide foraging and resting habitat for large waders	Fringing woodlands contribute organic debris and arboreal insects to wetlands; these are important food sources for wetland fauna. Large woody debris provides shelter for fish, substrates for biofilms and perching sites for waterbirds. Flooded tree canopies provide nesting sites for wetland bird species. (Ecological Associates, 2006). A healthy vegetation structure includes a diversity of species and age classes. It is important to ensure that a variety of age classes is maintained and to assist recruitment of the structural dominant species River Red Gum.	Catfish
Self-sustaining Murray Hardyhead population	The recently re-introduced Murray Hardyhead population is breeding. Ongoing management of the salinity, water regime, pest fish and wetland productivity is essential to maintain the population.	Brickworks Billabong
Extensive beds of Ruppia spp. In wetland	Murray Hardyhead need sufficient depth of water over Ruppia beds to allow successful spawning and recruitment in spring and summer, collated in (King et al., 2009).	Brickworks Billabong

Ecological objective	Justification	Wetland area
Provide shallow water habitat and exposure of mudflats to support foraging and resting of small waders	Six listed species of small migratory wading birds have been previously found within the target area. The fringing areas of semi-permanent saline wetlands provide suitable resting and foraging habitat for these species.	Brickworks Billabong

6.3 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 each of the ecological objectives are presented in Tables 13 - 15 and described below. The hydrological objectives tables identify the habitat zones, the prescribed water levels, frequency, duration and seasonality of watering to address the ecological objectives.

Water requirements for aquatic macrophytes vary depending on species, however annual inundation encourages germination, vegetative growth and reproduction (Rogers and Ralph, 2011). Inundation periods of six to twelve months are required to sustain vigorous growth, along with natural seasonal variation of water levels.

A flooding regime dominated by spring rather than summer flooding promotes higher macrophyte diversity and abundance (Robertston, Bacon and Heagney, 2001b). Semi-emergent macrophytes occupy shallower water that is generally flooded to a depth of one to two metres (Ecological Associates, 2006).

Flooding of wetland and floodplain vegetation in spring and summer provides a source of food, refuge and nesting sites and materials for waterbirds (Kingsford and Norman, 2002). Receding waters levels over summer provide shallow open water and mudflats which are important foraging habitat for wading birds (Ecological Associates, 2013).

Ellis and Wood (2015) recommend that annual drawdown of water level in summer will benefit Murray Hardyhead by:

- promoting sediment and nutrient consolidation and a subsequent productive pulse on inundation
- imposing increased saline stress on competing predatory species.

Ellis and Wood (2015) propose a water regime to maintain Murray Hardyhead populations (Table 12). This water regime has been recommended for Brickworks Billabong. Low water levels over summer also reduce the risk of Cumbungi beds dominating littoral vegetation.

Table 12 - Water regime proposed by Ellis and Wood, 2015 to maximise successful establishment and recruitment of Murray Hardyhead population.

Water level	Justification
Fill wetland from August to October (spring)	To inundate areas of exposed sediments, resulting in anticipated increase in zooplankton abundance and available vegetation to coincide with the breeding season
Cease water delivery in December to January to allow water level to decrease through summer	Expose areas of wetland sediments and create disconnection between waterbody and fringing vegetation. This allows for consolidation of sediments and germination of terrestrial plants on exposed areas of wetland sediments (which have been demonstrated to provide cover and spawning substrate upon re-inundation

In order to manage the spread of Cumbungi inflows must stop in October and November at the latest and then allow water levels to decrease through summer.

Significant depth to inundate Ruppia beds to allow successful spawning and recruitment in spring and summer (King et. al, 2009) is required by Murray Hardyhead. Adult Murray Hardyhead are tolerant of hypersaline water (Wedderburn, Walker and Zampatti, 2008) but eggs and larvae may be sensitive to high levels of salinity (Ellis, 2005) though the extent of the this tolerance isn't known (Ellis and Kavanaugh, 2014). Ruppia species can grow in water depths of 0.5 – 3m and regularly in salinities of 78,000 – 156,000 EC.

Table 13 - Hydrological objectives for Cowanna Billabong

Level (m AHD)	Zone	Timing	Frequency (years in 10)	Duration (months)
31.0	Maintain aquatic habitat	Winter	10	1-8
31.65	Inundate woodland perimeter	Spring	5	1-4
30.8	Maintain aquatic habitat / Expose woodland perimeter	Summer	10	1-4
29.5	Expose edges of wetland bed	Autumn	10	1-4

Table 14 - Hydrological objectives for Brickworks Billabong

Level (m AHD)	Zone	Timing	Frequency (years in 10)	Duration (months)
33.5	Maintain aquatic habitat	Winter	10	1-4
34.0	Inundate woodland perimeter	Spring	10	1-4
33.5	Expose woodland perimeter	Summer	10	1-4
33.0	Expose edges of wetland bed	Autumn	10	1-4

Table 15 - Hydrological objectives for Catfish Billabong

Level (m AHD)	Zone	Timing	Frequency (years in 10)	Duration (months)
32	Maintain aquatic habitat	Winter	10	1-8
33.5	Inundate woodland perimeter	Spring	5	1-4
30.8	Maintain aquatic habitat / Expose woodland perimeter	Summer/ Autumn	10	1-4

6.4 Watering regime

The wetland watering regime has been derived from the ecological and hydrological objectives. To allow for adaptive and integrated management, the hydrological objectives have been 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 watering regime is described below. Due to the inter-annual variability of these estimates (particularly the climatic conditions), determination of the predicted volume requirements in any given year will need to be undertaken by the environmental water manager when watering is planned.

The watering regime has been derived following review of the pre-regulation hydrology data.

Optimal watering regime

Cowanna Billabong

Maintain Cowanna Billabong as a permanent freshwater wetland, with seasonal variable water levels. Fill/top up Cowanna Billabong annually in late winter/ early spring to 31.65m AHD, allowing natural drawdown of the water level over summer/autumn. Ensure that permanent open water habitat is maintained by ensuring that water levels do not fall below 29.5m AHD.

A drying phase is to be introduced only as a Carp management tool. This should be enacted when there is evidence of abundant large Carp, or obvious decline in submergent macrophyte communities as a result of Carp.

Brickworks Billabong

Maintain Brickworks Billabong as a permanent saline wetland, with seasonally variable water levels. Fill/top up Brickworks Billabong annually in spring (August to October) to 34m AHD, allow the water level to decrease through late summer/autumn to a minimum of 33m AHD. Ensure that water level will maintain inundation of *Ruppia spp.* beds.

Catfish Billabong

Maintain Catfish Billabong as a permanent freshwater wetland, with seasonal variation in water levels. Surcharge Catfish Billabong via pumping to 33.5m AHD every second year in late winter/ early spring to inundate fringing woodland, then allow water levels to recede through summer/autumn. Ensure that aquatic habitat is retained by maintaining water levels at 30.8 m AHD in every year.

A drying phase is to be introduced only as a Carp management tool. This should be enacted when there is evidence of abundant large Carp, or obvious decline in submergent macrophyte communities as a result of Carp.

7 Managing risks to achieving objectives

Threat	Likelihood	Consequence	Risk – H, M, L (likelihood x consequence)	Management measure	Residual risk
Failure to meet ecological objectives	Possible	High	H	Monitoring program in place. Adaptive approach.	L
Species, communities or ecological functions have been overlooked in water regime due to lack of data	Possible	High	H	Review ecological survey results and update objectives if significant gaps are found.	L
Inundation duration too long or too short	Possible	High	H	Monitoring program in place. Adaptive approach as additional baseline and monitoring outcome data is available.	L
Environmental watering causes water quality issues (i.e. blackwater, Acid Sulphate Soil etc.)	Possible	Moderate	M	Observe water quality through watering season and manage accordingly.	L
Releases followed by heavy rainfall or high flow event causes flooding outside target area	Possible	Moderate	M	Observe long range weather forecasts, monitor Murray River flows, and manage delivery.	L
Water regime significantly enhances habitat for Carp	Likely	Moderate	M	Monitoring of Carp populations. Review of inlet and pumping equipment to screen Carp. Dry wetland out when Carp abundance reaches critical levels.	L
Salinity levels in Brickworks Billabong reach lethal levels for Murray Hardyhead adults	Possible	High	H	Monitor salinity levels and alter water regime if required to manage salinity	L

Threat	Likelihood	Consequence	Risk – H, M, L (likelihood x consequence)	Management measure	Residual risk
Salinity levels in Brickworks Billabong reach levels affecting breeding and recruitment of Murray Hardyhead (noting tolerances are unknown)	Possible	VH	VH	Monitor salinity levels and later water regime if required to manage salinity. Ensure that the best and most recent science is used to identify critical thresholds and prioritise further research in this area.	M
Extensive predation of Murray Hardyhead by large-bodied species following connection of Cowanna and Brickworks	Possible	High	H	Monitor fish populations in Brickworks regularly. Ensure fish screen on new regulator functions appropriately	L
Criminal damage or theft of water delivery infrastructure	Possible	Moderate	M	Utilise appropriate security devices on equipment and proactively engage with the community prior to watering event to gain support for the program.	L
Damage to infrastructure, particularly temporary stopbanks leading to loss of water from target area	Likely	Moderate	M	Appropriate engagement and site management in place. Regular monitoring and staff presence during watering events.	L
Maintenance required to delivery infrastructure (pump/channel etc.) during proposed watering event	Likely	High	VH	Include maintenance of channel on annual inspection checklist. Ensure pump contractors are appropriately qualified and have appropriate quality assurance processes in place.	L
Monitoring program is unable to detect improvement in short to medium term	Possible	High	H	Engagement with key stakeholders confirming expected outcomes, timeframes and assumptions.	L
Damage to cultural heritage sites through construction of temporary infrastructure and equipment	Possible	High	H	Site risk assessments undertaken and mitigations in place prior to any works occurring. Cultural Heritage Management Plans in place.	L

8 Environmental water delivery infrastructure

8.1 Constraints

Full inundation of the target area is not possible without the infrastructure and works recommendations listed below. The current area able to be inundated is shown in Figure 17.

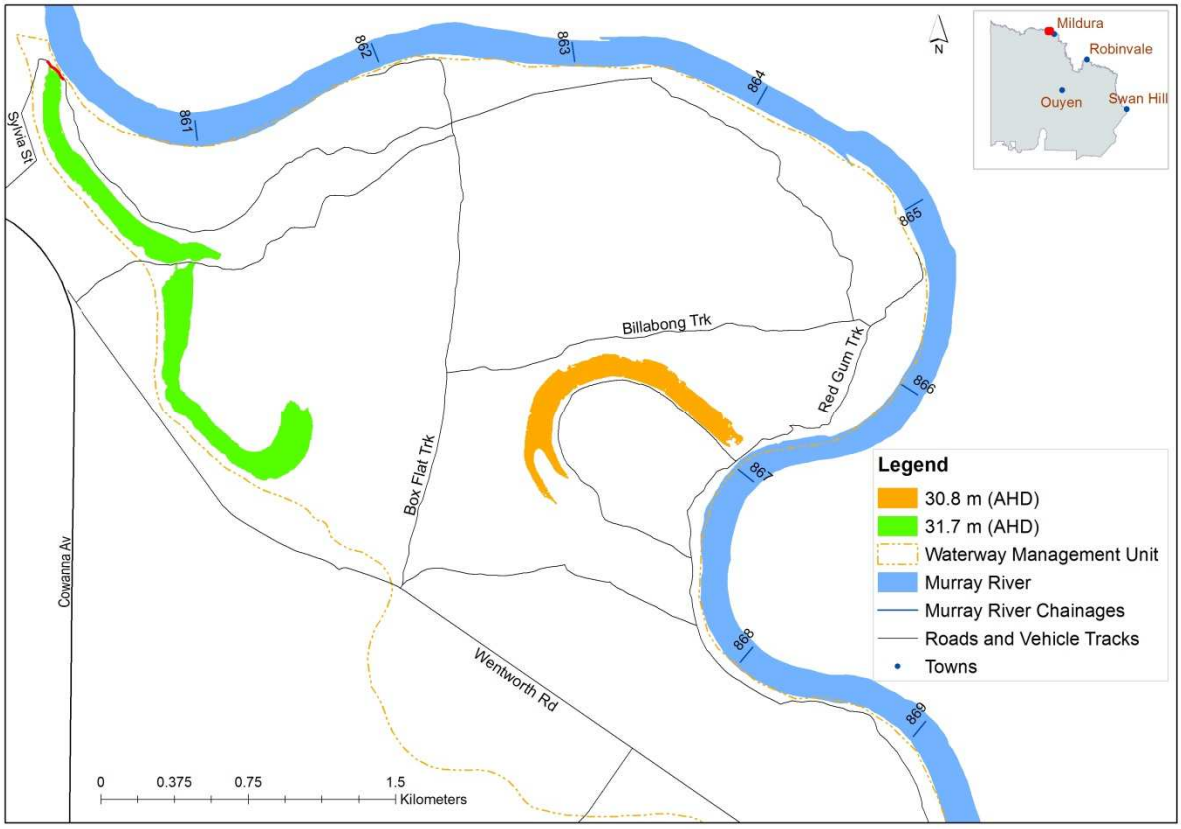


Figure 17 - Area currently able to be inundated without proposed infrastructure

8.2 Infrastructure or complementary works recommendations

In order to meet the recommended watering regime the following infrastructure is required:

Cowanna Billabong

No further infrastructure upgrades are required.

Brickworks Billabong

A concept design report has been undertaken by SMEC (2015) to understand the infrastructure requirements for Brickworks Billabong. The report recommends:

- Levee raising and a new regulator between Brickworks Billabong and Cowanna Billabong
- Levee raising at three sites to ensure that environmental water is maintained in a number of flood runners.

The proposed work has been designed on the basis of a target watering level of 34.0m AHD. Figure 18 shows the proposed infrastructure locations. The concept design report highlights some potential inconsistency in the LiDAR data used for the project and provides the maximum infrastructure requirements based on the known data. These details would need to be clarified in the detailed design phase.

Catfish Billabong

A regulator and road raising will be required for Catfish Billabong. Concept designs are required for this project. Indicative locations for the regulator and other infrastructure are shown in Figure 18.

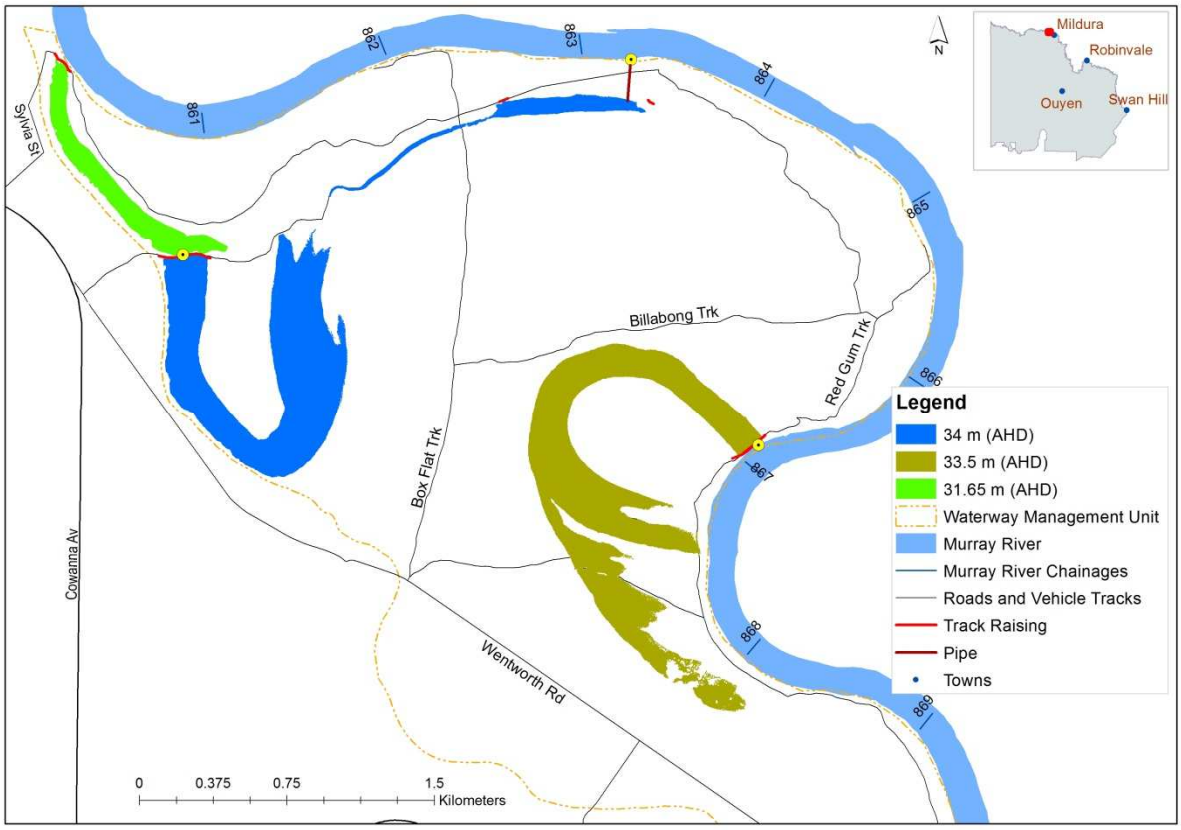


Figure 18 - Proposed infrastructure locations for Merbein Common

10 Demonstrating outcomes

10.1 Monitoring priorities at the site

The following priorities for monitoring have been identified for the Merbein Common target area:

- Index of wetland condition monitoring should be undertaken within the target area wetlands on a five-yearly basis, starting with a baseline monitoring.
- Photo point monitoring of tree health and aquatic vegetation within the wetlands.
- Fish surveys should be repeated as per existing methodology and Catfish Billabong should be added to the monitoring schedule.
- Continuous water quality (particularly DO and EC) and level monitoring should be undertaken within Brickworks Billabong. Level monitoring should be undertaken at Catfish Billabong and Cowanna Billabong.
- Monitoring of submergent macrophytes (particularly of Ruppia spp. within Brickworks and Catfish Billabong).

11 Consultation

This Plan was developed in collaboration with key stakeholders namely Parks Victoria, Nyeri Nyeri and Latji Latji community, the Department of Environment, Land, Water and Planning, and local interest groups.

Table 16 - Consultation for development of Merbein Common EWMP

Meeting Date	Stakeholders	Details
Sept 2012	Parks Victoria	Discussion of draft plan and request for formal input
Sept 2012	Friends Of Merbein Common (FOMC) meeting including representatives from Parks Victoria, Merbein Rotary Club, Merbein Historical Society, Yelta Landcare Group, Merbein Lions, Merbein Development Association	Presentation of draft plan and request for input/feedback
October 2012	Yelta Landcare Group	
May 2016	Friends of Merbein Common	Plan presentation
June 2016	Mildura BirdLife	Plan presentation

12 Knowledge gaps and recommendations

Detailed understanding of the watering regime required to maintain the saline habitat requirements of Brickworks Billabong for Murray Hardyhead

Salinity in Brickworks Billabong has been recorded between 6,000 and 76,000 EC over the last 40 years. With the implementation of better irrigation practices in the Yelta Irrigation District, inputs of salt to Brickworks Billabong from this source will be greatly reduced. The Parilla Sands aquifer continues to input salt to Brickworks Billabong. Monitoring of the recommended watering regime, along with salinity and water levels is required. This data will assist with understanding the long term watering regime required to maintain Brickworks Billabong as an appropriate saline habitat for Murray Hardyhead.

Salinity tolerances of Murray Hardyhead (eggs and larvae)

Adult Hardyhead are capable of surviving in very high salinities. However, the tolerance of larval Murray Hardyhead and eggs is not known. This is a key research area that would assist with managing the water regime at Merbein Common.

Salinity tolerances for key fish predators and competitors of Murray Hardyhead

Maintenance and expansion of the Murray Hardyhead population at Brickworks Billabong will require the continuation of the competitive advantage that higher salinity provides the species. Investigation into the key fish predators and competitors of Murray Hardyhead at Brickworks Billabong is required to determine the optimal salinity range that disadvantages these species while still allowing Murray Hardyhead breeding.

Detailed design report for Brickworks Billabong infrastructure

A detailed design report is required to scope the infrastructure requirements for Brickworks Billabong.

Concept design report for Catfish Billabong infrastructure

A concept design report is required to scope the infrastructure requirements for Catfish Billabong.

Index of Wetland Condition assessment

The target area wetlands should be incorporated into the five-yearly Index of Wetland Condition assessments.

Risk of Actual Acid Sulphate Soils – Catfish Billabong

Catfish Billabong is currently listed as a high risk for Acid Sulphate Soils. Investigation in to the risk of the potential acid sulphate soils oxidising as a result of implementing a variable water regime should be undertaken to ensure that adverse outcomes will not occur.

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Abbreviations and acronyms

CAMBA	China-Australia Migratory Bird Agreement
CMAs	Catchment Management Authorities
DELWP	Department of Environment, Land, Water and Planning
EVC	Ecological Vegetation Class
EWMP	Environmental Water Management Plan
FSL	Full Supply Level
MDBA	Murray-Darling Basin Authority (formally Murray-Darling Basin Commission, MDBC)
TSL	Targeted Supply Level
VEWH	Victorian Environmental Water Holder

Appendix 1 – Fauna species list

Lifeform type: Invertebrate, Fish, Amphibian, Reptile, Bird, Mammal

Common name	Scientific name	Type
Plains Froglet	*Crinia parinsignifera*	A
Common Froglet	*Crinia signifera*	A
Southern Bullfrog	*Limnodynastes dumerilii*	A
Barking Marsh Frog	*Limnodynastes fletcheri*	A
Spotted Marsh Frog (race unknown)	*Limnodynastes tasmaniensis*	A
Peron's Tree Frog	*Litoria peronii*	A
Growling Grass Frog	*Litoria raniformis*	A
Spiny-cheeked Honeyeater	*Acanthagenys rufogularis*	B
Yellow-rumped Thornbill	*Acanthiza chrysorrhoa*	B
Yellow Thornbill	*Acanthiza nana*	B
Chestnut-rumped Thornbill	*Acanthiza uropygialis*	B
Collard Sparrowhawk	*Accipiter cirrocephalus*	B
Australian Reed Warbler	*Acrocephalus australis*	B
Clamorous Reed Warbler	*Acrocephalus stentoreus*	B
Common Sandpiper	*Actitis hypoleucos*	B
Australian Owlet-nightjar	*Aegotheles cristatus*	B
Chestnut Teal	*Anas castanea*	B
Grey Teal	*Anas gracilis*	B
Australasian Shoveler	*Anas rhynchotis*	B
Pacific Black Duck	*Anas superciliosa*	B
Darter	*Anhinga novaehollandiae*	B
Red Wattlebird	*Anthochaera carunculata*	B
Intermediate Egret	*Ardea intermedia*	B
Eastern Great Egret	*Ardea modesta*	B
White-necked Heron	*Ardea pacifica*	B
White-breasted Woodswallow	*Artamus leucorynchus*	B
White-browed Woodswallow	*Artamus superciliosus*	B
Hardhead	*Aythya australis*	B

Common name	Scientific name	Type
Australian Ringneck	*Barnardius zonarius*	B
Mallee Ringneck	*Barnardius zonarius barnardi*	B
Musk Duck	*Biziura lobata*	B
Galah	*Cacatua (Eolophus) roseicapilla*	B
Little Corella	*Cacatua sanguinea*	B
Curlew Sandpiper	*Calidris ferruginea*	B
Red-necked Stint	*Calidris ruficollis*	B
Gold fish*	*Carassius auratus*	B
European Goldfinch*	*Carduelis carduelis*	B
Red-capped Plover	*Charadrius ruficapillus*	B
Australian Wood Duck	*Chenonetta jubata*	B
White-backed Swallow	*Cheramoeca leucosternus*	B
Whiskered Tern	*Chlidonias hybrida*	B
Silver Gull	*Chroicocephalus novaehollandiae*	B
Horsfield's Bronze-Cuckoo	*Chrysococcyx basalis*	B
Rufous Songlark	*Cincloramphus mathewsi*	B
Swamp Harrier	*Circus approximans*	B
Brown Treecreeper	*Climacteris picumnus picumnus*	B
Brown Treecreeper (south-eastern ssp.)	*Climacteris picumnus victoriae*	B
Grey Shrike-thrush	*Colluricincla harmonica*	B
Rock Dove*	*Columba livia*	B
Black-faced Cuckoo-shrike	*Coracina novaehollandiae*	B
White-winged Chough	*Corcorax melanorhamphos*	B
Australian Raven	*Corvus coronoides*	B
Little Raven	*Corvus mellori*	B
Pied Butcherbird	*Cracticus nigrogularis*	B
Australian Magpie	*Cracticus tibicen*	B
Grey Butcherbird	*Cracticus torquatus*	B
Pallid Cuckoo	*Cuculus pallidus*	B
Black Swan	*Cygnus atratus*	B

Common name	Scientific name	Type
Laughing Kookaburra	*Dacelo novaeguineae*	B
Varied Sittella	*Daphoenositta chrysoptera*	B
Mistletoebird	*Dicaeum hirundinaceum*	B
Little Egret	*Egretta garzetta nigripes*	B
White-faced Heron	*Egretta novaehollandiae*	B
Black-fronted Dotterel	*Elseyornis melanops*	B
Blue-faced Honeyeater	*Entomyzon cyanotis*	B
Galah	*Eolophus roseicapilla*	B
Orange Chat	*Epthianura aurifrons*	B
Red-kneed Dotterel	*Erythrogonys cinctus*	B
Dollarbird	*Eurystomus orientalis*	B
Nankeen Kestrel	*Falco cenchroides*	B
Australian Hobby	*Falco longipennis*	B
Peregrine Falcon	*Falco peregrinus*	B
Eurasian Coot	*Fulica atra*	B
Red-naped Snake	*Furina diadema*	B
Dusky Moorhen	*Gallinula tenebrosa*	B
Peaceful Dove	*Geopelia striata*	B
Western Gerygone	*Gerygone fusca*	B
Magpie Lark	*Grallina cyanoleuca*	B
Brolga	*Grus rubicunda*	B
Australian Magpie	*Gymnorhina tibicen*	B
White-bellied Sea-Eagle	*Haliaeetus leucogaster*	B
Whistling Kite	*Haliastur sphenurus*	B
Little Eagle	*Hieraaetus morphnoides*	B
Black-winged Stilt	*Himantopus himantopus*	B
Welcome Swallow	*Hirundo neoxena*	B
Tree Martin	*Hirundo nigricans*	B
Caspian Tern	*Hydroprogne caspia*	B
White-plumed Honeyeater	*Lichenostomus penicillatus*	B

Common name	Scientific name	Type
Singing Honeyeater	*Lichenostomus virescens*	B
Black-tailed Godwit	*Limosa limosa*	B
Square-tailed Kite	*Lophoictinia isura*	B
Pink-eared Duck	*Malacorhynchus membranaceus*	B
Superb Fairy-wren	*Malurus cyaneus*	B
Variegated Fairy-wren	*Malurus lamberti*	B
White-winged Fairy-wren	*Malurus leucopterus*	B
Noisy Miner	*Manorina melanocephala*	B
Little Grassbird	*Megalurus gramineus*	B
Rainbow Bee-eater	*Merops ornatus*	B
Little Pied Cormorant	*Microcarbo melanoleucos*	B
Black Kite	*Milvus migrans*	B
Restless Flycatcher	*Myiagra inquieta*	B
Blue-winged Parrot	*Neophema chrysostoma*	B
Blue Bonnet	*Northiella haematogaster*	B
Cockatiel	*Nymphicus hollandicus*	B
Crested Pigeon	*Ocyphaps lophotes*	B
Blue-billed Duck	*Oxyura australis*	B
Rufous Whistler	*Pachycephala rufiventris*	B
Spotted Pardalote	*Pardalotus punctatus punctatus*	B
Striated Pardalote	*Pardalotus striatus*	B
Australian Pelican	*Pelecanus conspicillatus*	B
Fairy Martin	*Petrochelidon ariel*	B
Welcome Swallow	*Petrochelidon neoxena*	B
Tree Martin	*Petrochelidon nigricans*	B
Red-capped Robin	*Petroica goodenovii*	B
Great Cormorant	*Phalacrocorax carbo*	B
Little Pied Cormorant	*Phalacrocorax melanoleucos*	B
Little Black Cormorant	*Phalacrocorax sulcirostris*	B
Pied Cormorant	*Phalacrocorax varius*	B

Common name	Scientific name	Type
Common Bronzewing	*Phaps chalcoptera*	B
Little Friarbird	*Philemon citreogularis*	B
Noisy Friarbird	*Philemon corniculatus*	B
Yellow-billed Spoonbill	*Platalea flavipes*	B
Royal Spoonbill	*Platalea regia*	B
Crimson Rosella	*Platycercus elegans*	B
Crimson Rosella	*Platycercus elegans*	B
Yellow Rosella	*Platycercus elegans flaveolus*	B
Striped Honeyeater	*Plectorhyncha lanceolata*	B
Glossy Ibis	*Plegadis falcinellus*	B
Pacific Golden Plover	*Pluvialis fulva*	B
Tawny Frogmouth	*Podargus strigoides*	B
Great Crested Grebe	*Podiceps cristatus*	B
Hoary-headed Grebe	*Poliocephalus poliocephalus*	B
Chestnut-crowned Babbler	*Pomatostomus ruficeps*	B
White-browed Babbler	*Pomatostomus superciliosus*	B
Purple Swamphen	*Porphyrio porphyrio*	B
Spotless Crake	*Porzana tabuensis*	B
Red-rumped Parrot	*Psephotus haematonotus*	B
Mulga Parrot	*Psephotus varius*	B
Red-necked Avocet	*Recurvirostra novaehollandiae*	B
Willie Wagtail	*Rhipidura leucophrys*	B
Weebill	*Smicrornis brevirostris*	B
Caspian Tern	*Sterna caspia*	B
Freckled Duck	*Stictonetta naevosa*	B
Grey Currawong	*Strepera versicolor*	B
Apostlebird	*Struthidea cinerea*	B
Common Starling*	*Sturnus vulgaris*	B
Australasian Grebe	*Tachybaptus novaehollandiae*	B
Australian Shelduck	*Tadorna tadornoides*	B

Common name	Scientific name	Type
Zebra Finch	*Taeniopygia guttata*	B
Australian White Ibis	*Threskiornis molucca*	B
Straw-necked Ibis	*Threskiornis spinicollis*	B
Sacred Kingfisher	*Todiramphus sanctus*	B
Rainbow Lorikeet	*Trichoglossus haematodus*	B
Wood Sandpiper	*Tringa glareola*	B
Common Greenshank	*Tringa nebularia*	B
Marsh Sandpiper	*Tringa stagnatilis*	B
Common Blackbird*	*Turdus merula*	B
Masked Lapwing	*Vanellus miles*	B
Banded Lapwing	*Vanellus tricolor*	B
Murray Hardyhead	*Craterocephalus fluviatilis*	F
Unspecked Hardyhead	*Craterocephalus stercusmuscarum fulvus*	F
European Carp*	*Cyprinus carpio*	F
Eastern Gambusia*	*Gambusia holbrooki*	F
Western Carp Gudgeon	*Hypseleotris klunzingeri*	F
Spangled Perch	*Leiopotherapon unicolor*	F
Golden Perch	*Macquaria ambigua*	F
Inland River Prawn	*Macrobrachium australiense*	F
Murray-Darling Rainbow Fish	*Melanotaenia fluviatilis*	F
Bony Herring	*Nematalosa erebi*	F
European Perch*	*Percia Fluviatilis*	F
Flathead Gudgeon	*Philypnodon grandiceps*	F
Australian Smelt	*Retropinna semoni*	F
Freshwater Shrimp	*Paratya australiensis*	I
Black Rat*	*Rattus rattus*	I
Slow Water Mussel	*Velesunio ambiguus*	I
Eastern Grey Kangaroo	*Macropus giganteus*	M
Rabbit*	*Oryctolagus cuniculus*	M
Common Brushtail Possum	*Trichosurus vulpecula*	M

Common name	Scientific name	Type
Carnaby's Wall Skink	*Cryptoblepharus carnabyi*	R
Ragged Snake-eyed Skink	*Cryptoblepharus pannosus*	R
Regal Striped Skink	*Ctenotus regius*	R
Yellow-faced Whip Snake	*Demansia psammophis*	R
Tessellated Gecko	*Diplodactylus tessellatus*	R
Murray Short-necked Turtle	*Emydura macquarii*	R
Tree Dtella Gecko	*Gehyra variegata*	R
Bynoe's Gecko	*Heteronotia binoei*	R
Spotted Burrowing Skink	*Lerista punctatovittata*	R
Broad-shelled Turtle	*Macrochelodina expansa*	R
Grey's Skink	*Menetia greyii*	R
Carpet Python	*Morelia spilota metcalfei*	R
Boulenger's Skink	*Morethia boulengeri*	R
Mitchell's Short-tailed Snake	*Parasuta nigriceps*	R
Marbled Gecko	*Phyllodactylus marmoratus*	R
Eastern Brown Snake	*Pseudonaja textilis*	R
Stumpy-tailed Lizard	*Tiliqua rugosa*	R
Lace Monitor	*Varanus varius*	R

*Introduced species

Lifeform type: Invertebrate (I), Fish (F), Amphibian (A), Reptile (R), Bird (B), Mammal (M)

Source:(GHD, 2016b; a; Biosis, 2016, DELWP, 2016b; unpublished fish survey data - Mallee CMA)

Appendix 2 – Ecological vegetation classes (EVCs)

EVC no.	EVC name	Bioregional conservation status	Description
102	Low Chenopod Shrubland	Depleted	Chenopod shrubland to 1 m tall occupying broad, flat alluvial terraces occur along the Murray River, west from Mildura to the border. Also found in narrow bands fringing raak and saline lakes such as Lake Tyrell and on relict lakebed surfaces such as Pine Plains. The field layer is characterised by succulents and a suite of annual herbs.
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.
104	Lignum Swamp	Vulnerable	Typically treeless shrubland to 4 m tall with robust (but sometimes patchy) growth of lignum. Widespread wetland vegetation type in low rainfall areas on heavy soils, subject to infrequent inundation resulting from overbank flows from rivers or local runoff.
806	Alluvial plains semi-arid grassland	Vulnerable	Grassland (turf) to herbland to < 0.2 m tall with only incidental shrubs. Flood-promoted flora, potentially including a wide range of opportunistic ephemeral / annual species occupying low-lying areas within at least previously flood-prone (mostly) higher-level terraces, which may be effectively shallow lakes when flooded. Also sometimes on flats along creeks of the further north-west, in habitat akin to that of Floodway Pond Herbland.
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 by the open and even distribution of relatively small Lignum shrubs. Occupies heavy soil plains along Murray River, low-lying areas on higher-level (but still potentially flood-prone) terraces.
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.

EVC no.	EVC name	Bioregional conservation status	Description
818	Shrubby Riverine Woodland	Least concern	Eucalypt woodland to open forest to 15 m tall of less flood-prone (riverine) watercourse fringes, principally on levees and higher sections of point-bar deposits. The understorey includes a range of species shared with drier floodplain habitats with a sparse shrub component, ground-layer patchily dominated by various life-forms. A range of large dicot herbs (mostly herbaceous perennial, several with a growth-form approaching that of small shrub) are often conspicuous.
823	Lignum Swampy Woodland	Depleted	Understorey dominated by Lignum, typically of robust character and relatively dense (at least in patches), in association with a 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.

Source: (DSE, 2013; DELWP, 2016a)

Appendix 3 – Flora species list

Common name	Scientific name
Dwarf Lantern-flower	*Abutilon fraseri*
Desert Lantern	*Abutilon otocarpum*
Nealie	*Acacia loderi*
Yarran	*Acacia melvillei*
Spine Bush	*Acacia nyssophylla*
Bramble Wattle	*Acacia victoriae* subsp. *victoriae*
Cattle Bush	*Alectryon oleifolius* subsp. *canescens*
Camel Thorn*	*Alhagi maurorum*
Common Joyweed	*Alternanthera nodiflora*
Tall Kerosene Grass	*Aristida holathera* var. *holathera*
Onion Weed*	*Asphodelus fistulosus*
Composite	*Asteraceae* spp.
Flat-top Saltbush	*Atriplex lindleyi*
Old-man Saltbush	*Atriplex nummularia*
Silver Saltbush	*Atriplex rhagodioides*
Variable Daisy	*Brachyscome ciliaris*
Leek Lily	*Bulbine semibarbata*
Slender Cypress-pine	*Callitris gracilis*
Blue Burr-daisy	*Calotis cuneifolia*
Inland Pigface	*Carpobrotus modestus*
Ward's Weed*	*Carrichtera annua*
Belah	*Casuarina pauper*
Common Sneezeweed	*Centipeda cunninghamii*
Spreading Sneezeweed	*Centipeda minima subsp. minima* s.s.
Cottony Saltbush	*Chenopodium curvispicatum*
Nitre Goosefoot	*Chenopodium nitrariaceum*
Flaxleaf Fleabane*	*Conyza bonariensis*
Rosinweed	*Cressa australis*

Common name	Scientific name
Devil's Rope*	*Cylindropuntia imbricata* var. *imbricata*
Rounded Noon-flower	*Disphyma crassifolium* subsp. *clavellatum*
Hard-head Saltbush	*Dissocarpus paradoxus*
Sticky Hop-bush	*Dodonaea viscosa*
Spiny Lignum	*Duma horrida* subsp. *horrida*
Smooth Elachanth	*Elachanthus glaber*
Ruby Saltbush	*Enchylaena tomentosa* var. *tomentosa*
Spider Grass	*Enteropogon acicularis*
Bristly Love-grass	*Eragrostis setifolia*
Spreading Emu-bush	*Eremophila divaricata* subsp. *divaricata*
Common Emu-bush	*Eremophila glabra*
Spotted Emu-bush	*Eremophila maculata* subsp. *maculata*
Narrow-leaf Emu-bush	*Eremophila sturtii*
River Red-gum	*Eucalyptus camaldulensis*
Dumosa Mallee	*Eucalyptus dumosa*
Black Box	*Eucalyptus largiflorens*
Eucalypt	*Eucalyptus spp.*
Flat Spurge	*Euphorbia drummondii* s.l.
Leafless Ballart	*Exocarpos aphyllus*
Leafy Sea-heath	*Frankenia foliosa*
Bristly Sea-heath	*Frankenia serpyllifolia*
Cut-leaf Goodenia	*Goodenia pinnatifida*
Goodenia	*Goodenia spp.*
Silver Needlewood	*Hakea leucoptera* subsp. *leucoptera*
Jersey Cudweed	*Helichrysum luteoalbum*
Prickly Lettuce*	*Lactuca serriola*
Hoary Cress*	*Lepidium draba*
African Box-thorn*	*Lycium ferocissimum*
Black Cotton-bush	*Maireana decalvans* s.l.

Common name	Scientific name
Sago Bush	*Maireana pyramidata*
Pearl Bluebush	*Maireana sedifolia*
Satiny Bluebush	*Maireana turbinata*
Goat Head	*Malacocera tricornis*
Doubah	*Marsdenia australis*
Common Nardoo	*Marsilea drummondii*
Sugarwood	*Myoporum platycarpum*
Riverina Pear*	*Opuntia elata*
Babbagia	*Osteocarpum acropterum* var. *deminutum*
Fog-fruit*	*Phyla canescens*
Sandhill Spurge	*Phyllanthus lacunellus*
Weeping Pittosporum	*Pittosporum angustifolium*
Hedge Saltbush	*Rhagodia spinescens*
Curled Dock*	*Rumex crispus*
Sarcozona	*Sarcozona praecox*
Pepper Tree*	*Schinus molle*
Grey Copperburr	*Sclerolaena diacantha*
Streaked Copperburr	*Sclerolaena tricuspis*
Variable Groundsel	*Senecio pinnatifolius*
Cotton Fireweed	*Senecio quadridentatus*
Desert Cassia	*Senna artemisioides* s.l.
Fine-leaf Desert Cassia	*Senna form taxon 'filifolia'*
Twiggy Sida	*Sida intricata*
Quena	*Solanum esuriale*
Black Nightshade*	*Solanum nigrum* s.s.
Common Sow-thistle*	*Sonchus oleraceus*
Small-leaf Swainson-pea	*Swainsona microphylla*
Bluish Glasswort	*Tecticornia pruinosa*
Fuzzy New Holland Daisy	*Vittadinia cuneata*

Common name	Scientific name
River Bluebell	*Wahlenbergia fluminalis*
Pointed Twin-leaf	*Zygophyllum apiculatum*

*Introduced species

Source: (DELWP, 2016)