Murrumbidgee Junction Environmental Water Management Plan

Document Control

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4.	Updated watering history and changed wetland name from Nurrung wetlands to Bidgee Lagoons (Nurrung Wetlands) as per the strategy.	J. White	2/2/2018

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Cover photo: A. Edwards 26/07/2011 in (Bell, 2012).

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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 them into planning units. This EWMP has been developed for the Murrumbidgee Junction WMU sub-unit. Hereafter referred to as Murrumbidgee Junction. The EWMP will help to guide future environmental watering activities for this area.

Murrumbidgee Junction is situated on the Murray River floodplain, south east of Robinvale near Narrung. Murrumbidgee Junction falls within Murray River Park, with a small area covering part of Wakool Creek crossing through private land.

The combination of Lignum Shrublands and the wetland woodland mosaic found at Murrumbidgee Junction provide a great diversity of feeding, breeding and nursery sites for native water-dependent biota. Under pre-regulation conditions the Bidgee Lagoons (Narrung Wetlands) would have flooded in almost every year, providing permanent aquatic habitat within the forest.

The mature River Red Gum at this site are providing essential habitat for listed species including Carpet Python and Regent Parrot. Mature River Red Gum are also an important source of fallen timber habitat for Carpet Python on the floodplain.

Environmental watering at Murrumbidgee Junction in 2005/2006 was successful in ameliorating stress in the River Red Gums, and the watering also promoted River Red Gum recruitment within the Bidgee Lagoons (Narrung Wetlands). These young River Red Gum are now in poor condition due to prolonged dry conditions.

The management goal for the Murrumbidgee Junction EWMP is to provide a water regime for the Bidgee Lagoons (Narrung Wetlands) and Wakool Creek with a more natural frequency and duration that will maintain and promote the health of the mature River Red Gum and encourage regeneration and ecosystem productivity within the Murrumbidgee Junction target area. The target area for the Murrumbidgee Junction EWMP includes the Bidgee Lagoons (Narrung Wetlands) (also known as Bidgee Lagoons) and Wakool Creek.

To achieve the management goal, ecological and hydrological objectives have been defined to provide an appropriate environmental watering regime. The ecological objectives are based on the values that the Murrumbidgee Junction target area is likely to support. They are:

- Maintain a healthy and productive wetland woodland mosaic (particularly Ecological Vegetation Classes (EVC) 809, 810,818, 200).
- Maintain mature River Red Gum which provide nesting, roosting and structural habitat for Carpet Python, White-bellied Sea-eagle, Regent Parrot and Major Mitchell's Cockatoo.
- Promote a healthy and productive Lignum Shrubland (EVC 808) providing habitat for waterbird nesting and roosting.
- Sustain resident populations of small-bodied native fish and opportunistic use by large-bodied native fish through maintenance of permanent pool habitat.
- Promote seasonal emergent and semi-emergent macrophytes.

Hydrological objectives for the Murrumbidgee Junction target area are provided for minimum, optimal and maximum water availability conditions. The optimal water regime for Bidgee Lagoons (Narrung Wetlands) and Wakool Creek is provided below.

Bidgee Lagoons (Narrung Wetlands)

Fill Bidgee Lagoons (Narrung Wetlands) to 54.4 mAHD in spring three times in ten years targeting the health and productivity of the River Red gum dominated wetland woodland mosaic. Ensure that the water level remains at wetland capacity for three months. Allow water to draw down naturally over the subsequent season allowing exposure of the littoral zone and promotion of aquatic macrophytes. Top up as necessary, keeping water level at 52.1 mAHD to ensure that pool habitat for small-bodied native fish and other aquatic fauna is permanently maintained.

Wakool Creek

Fill Wakool Creek, from the upstream pump site, to 55.4 mAHD five times in ten years with the aim of promoting healthy lignum shrubs with vigorous canopy capable of supporting waterbird nesting and roosting. Ensure water levels remain at this level for five months to provide opportunities for waterbirds, such as cormorants and darters, to fledge.

Infrastructure is required to enable the efficient and effective delivery of environmental water to both Bidgee Lagoons (Narrung Wetlands) and Wakool Creek. Detailed design and cultural heritage planning has been undertaken for infrastructure construction at Bidgee Lagoons (Narrung Wetlands).

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 Murrumbidgee Junction.

The key purposes of the EWMP are to:

- identify the long-term objectives and water requirements for the wetland, identified as a high priority by the 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), with 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 irrigation of grapes, citrus, almonds, olives and vegetables along the Murray River corridor which contributes 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 of another FMU, 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 Murrumbidgee Junction FMU, hereafter referred to as Murrumbidgee Junction in this document. Murrumbidgee Junction is located within the Boundary Bend WMU, 45km south east of Robinvale 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.

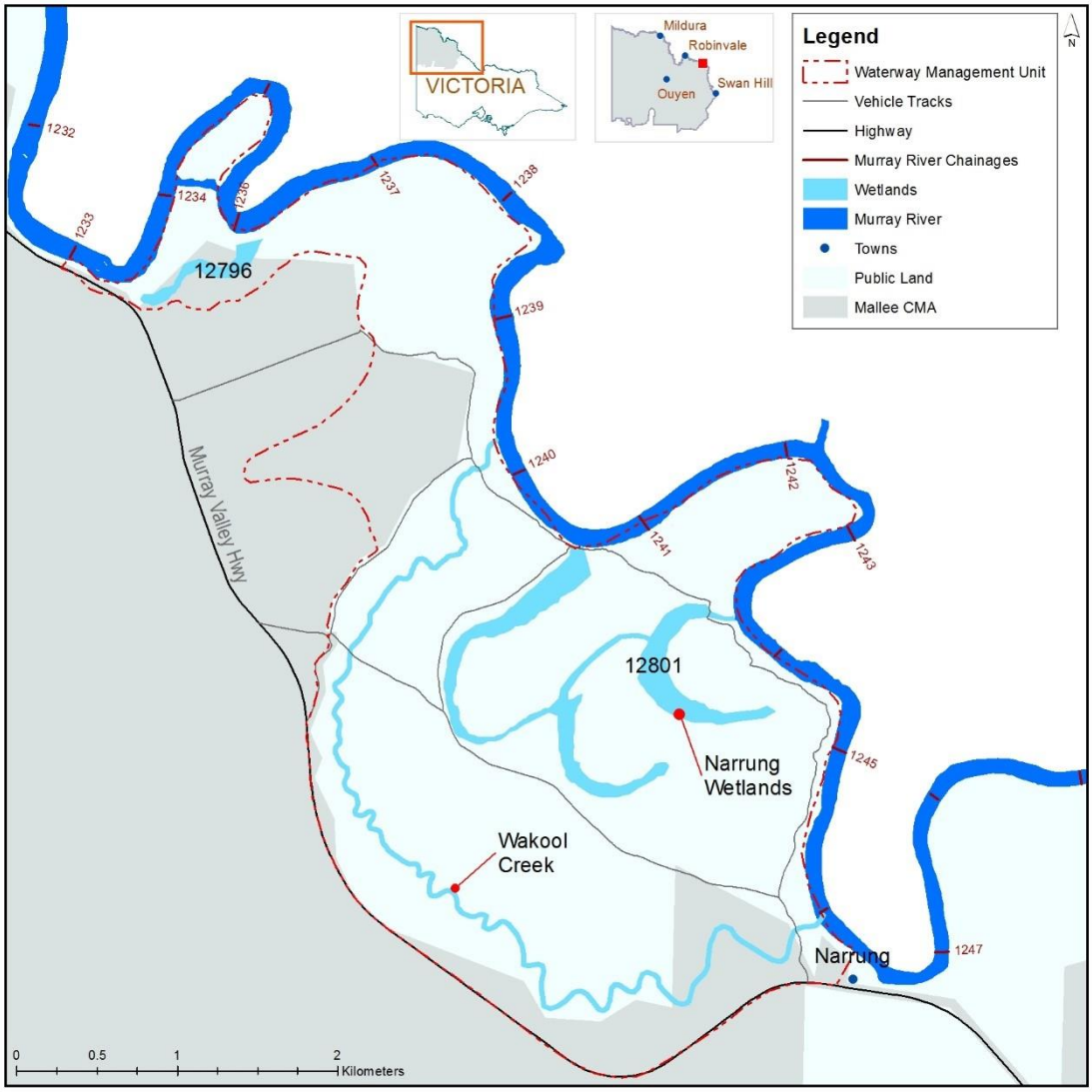


Figure 1 - Murrumbidgee Junction

2.2 Catchment setting

Murrumbidgee Junction is located within the Murray Fans bioregion within the Mallee CMA region. The Murray Fans bioregion is characterised by a flat to gently undulating landscape on recent unconsolidated sediments with evidence of former stream channels, old river meanders and paleochannels and broad floodplain areas associated with major river systems and prior streams (known as braided / anastomosing streams). Alluvium deposits from the Cainozoic period gave rise to the red brown earths and texture contrast soils (Dermosols, Kurosols, Chromosols and Sodosols) (DEPI, 2015).

2.3 Murrumbidgee Junction

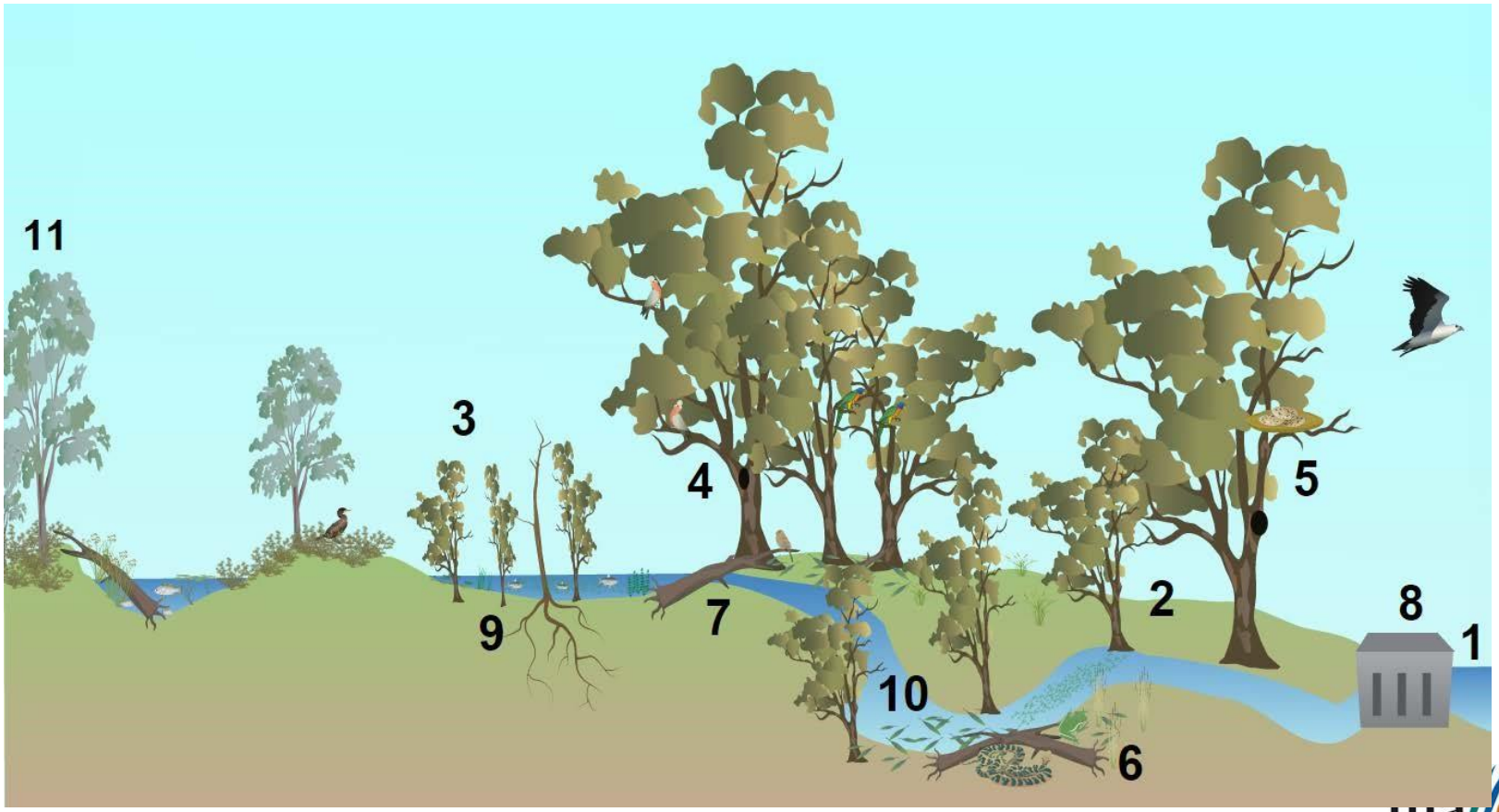
Murrumbidgee Junction is situated on the Murray River floodplain, south east of Robinvale near Narrung.

There are five distinct wetlands present; three connected deep freshwater billabongs known as Bidgee Lagoons (Narrung Wetlands) (wetland #12801), one distinct shallow freshwater marsh (#12796) and the freshwater meadow within Wakool Creek. Wakool Creek has a poorly defined channel for much of its length, with no distinct banks.

Murrumbidgee Junction falls within Murray River Park, with a small area covering part of Wakool Creek crossing through private land. Adjacent landuses include dryland cropping and irrigated horticulture.

2.4 Conceptualisation of the site

Murrumbidgee Junction is represented in the conceptual model below. This is a visual representation of the processes and components within the target area that are discussed throughout this EWMP.



Wakool Creek diverges from the Murray River at chainage 1246 near Narrung and follows the perimeter of Murrumbidgee Junction, returning to the river at chainage 1240.

Bidgee Lagoons (Narrung Wetlands) is a group of three connected billabongs in the central part of the floodplain. The wetlands are connected to the Murray River at the downstream end at chainage 1240.5 and, at higher flows, at an upstream connection at chainage 1243.5. The surrounding floodplain supports River Red Gum and Black Box woodland.

1. River regulation and water extraction for irrigation have reduced the frequency and duration of inundation of floodplain wetlands in this section of the Murray River. Under pre-regulation conditions Bidgee Lagoons (Narrung Wetlands) would have been inundated almost every year. The frequency and duration of inundation has been almost halved.
2. Reduced floodplain and wetland inundation has contributed to reductions in the diversity and productivity of riparian and floodplain vegetation communities and a reduction in habitat availability and structural complexity for aquatic and terrestrial fauna.
3. Previous environmental watering following prolonged dry conditions resulted in improved River Red Gum health and recruitment within the wetlands. Improved inundation regimes based on modelled natural water regimes and the requirements of the vegetation communities are expected to increase the health and productivity of the wetland woodland vegetation mosaic and aid in nutrient cycling.
4. Significant mature, hollow bearing River Red Gum are plentiful at the site, lining the connecting channels and wetlands.
5. Hollows in mature River Red Gum provide important habitat for fauna including Regent Parrot, Major Mitchell's Cockatoo, Carpet Python and White-bellied Sea-eagle.
6. Fallen woody debris provides feeding sites for ground foraging birds such as the Brown Tree-creeper; thick leaf litter and fallen logs with hollows provide shelter for the Carpet Python.
7. The floodplain supports a mosaic of Floodway Pond Herbland (EVC 810), Shallow Freshwater Marsh (EVC 200), Floodplain Grassy Wetland (EVC 809) and Forest Herbland complex in the wetlands and channels.
8. Proposed regulators and stop gates will allow water to be captured and retained in the Bidgee Lagoons (Narrung Wetlands) and Wakool Creek following high river flows and will allow pumped environmental watering. This will contribute to maintenance of the values of the site.
9. During high river flows, small bodied fish and juvenile Golden Perch may use Bidgee Lagoons (Narrung Wetlands) and Wakool Creek for feeding, shelter, and spawning. The proposed regulators can be opened on flood recession to allow fish to exit the wetland.
10. The movement of water between Wakool Creek, smaller floodplain channels, Bidgee Lagoons (Narrung Wetlands) and the Murray River will entrain nutrients, release seed, maintain frog diversity and increase macrophyte diversity.
11. Lignum Shrubland within Wakool Creek may provide habitat for waterbird roosting and nesting.

Graphic 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 Murrumbidgee Junction (Table 1). Land management boundaries are shown in Figure 2.

Murrumbidgee Junction has historically been managed as State Forest (Murrumbidgee State Forest) as part of the Murray River Reserve, as recommended in the Land Conservation Council Final Recommendations (LCC, 1989). The area is now part of the Murray River Park with Parks Victoria as the land manager. This recommendation came into effect in July 2010.

Table 1 - Stakeholders for the Murrumbidgee Junction 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
Robinvale Claimant Group, Tati Tati and Latji Latji representatives	Indigenous representation
Local landholders	Assistance in planning and implementation of programs

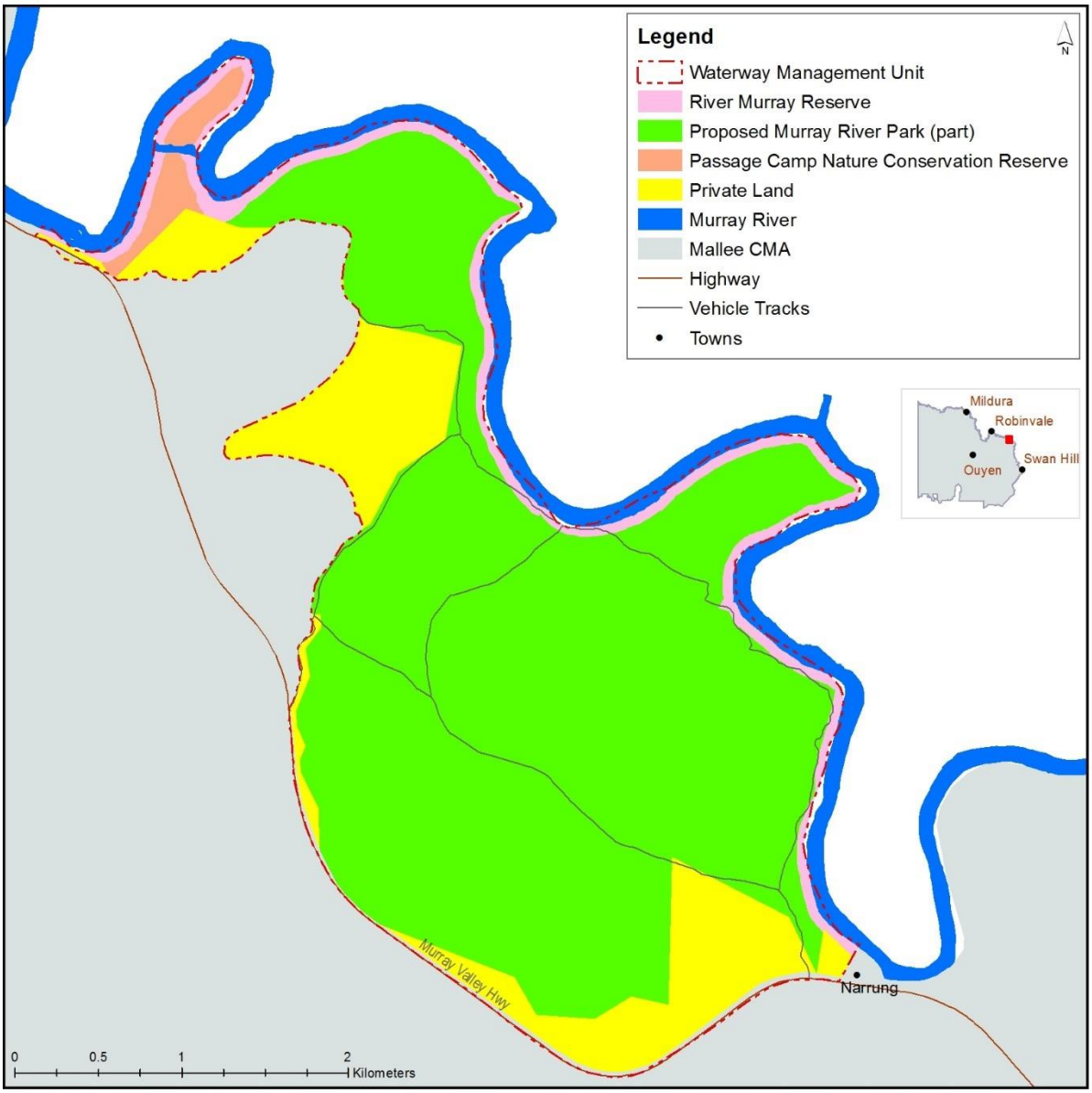


Figure 2 - Land management boundaries within Murrumbidgee Junction

2.6 Wetland characteristics

A brief overview of the main characteristics of the wetlands at Murrumbidgee Junction is provided in Table 2.

Table 2 - Wetland characteristics at Murrumbidgee Junction

Characteristics	Description
Name	Murrumbidgee Junction
Mapping ID (Wetland Current layer)	**Bidgee Lagoons (Narrung Wetlands):** 12801 **Wakool Creek:** not listed **Other Wetlands:** 12796
Area of wetlands in target area	68 ha

Bioregion	The majority of the site is within the Murray Fans bioregion, a small section falls within Murray Mallee.
Conservation status	Bioregional Conservation Status: areas of EVCs listed as endangered, vulnerable, depleted and least concern.
Land status	Murray River Park, Passage Camp Nature Conservation Reserve, private land
Land manager	Parks Victoria, DELWP, private
Surrounding land use	Farming zone: broad acre dryland cropping and irrigated horticulture; townships of Boundary Bend and Narrung
Water supply	Natural inflows from the Murray River and local catchment runoff
1788 wetland category (Wetland PreEuropean layer)	**Bidgee Lagoons (Narrung Wetlands)** 75289534, 752815527 and 752821532: Deep Freshwater Marsh **Wakool Creek** 752814514: Freshwater Meadow **Other Wetlands** 75288543 and 7528995557: Shallow Freshwater Marsh
2013 wetland category (Wetland Current layer)	**Bidgee Lagoons (Narrung Wetlands)** 75289534, 752815527, 752821532: Combined into #12801, wetland type unknown **Wakool Creek** 752814514: not listed in this layer **Other Wetlands** 75288543: not listed in this layer 7528995557: #12796, wetland type unknown
Wetland depth at capacity	Approximately 4 metres at deepest point

2.7 Management scale

The whole of Murrumbidgee Junction has a water requirement as a floodplain complex, but the focus of this plan is restricted to a target area of 97.37ha, as shown as the maximum inundation extent in Figure 3.

This target area, consisting of Bidgee Lagoons (Narrung Wetlands) and Wakool Creek, is the area of Murrumbidgee Junction that is able to be managed with environmental water, 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.

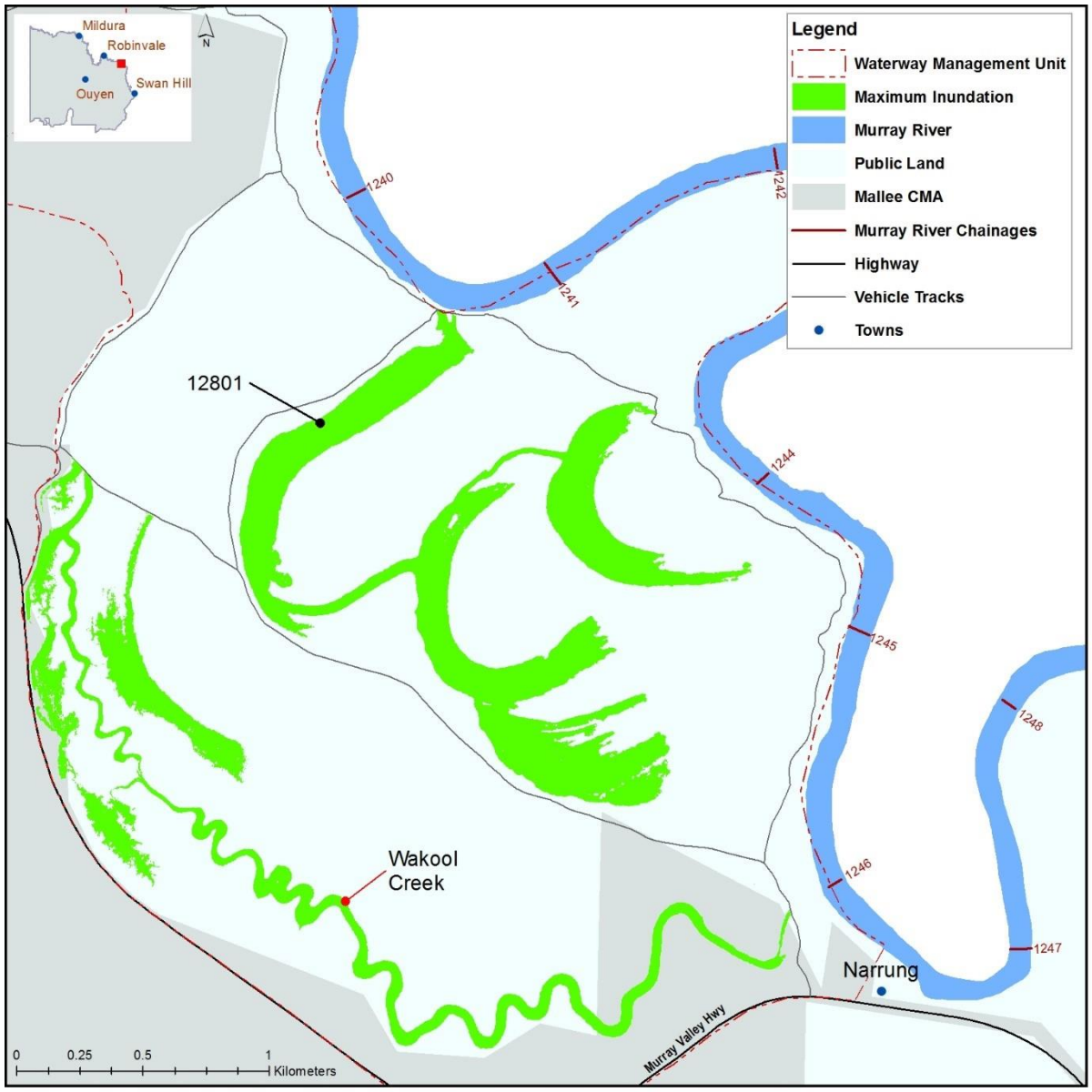


Figure 3 - Target area for the Murrumbidgee Junction EWMP consisting of the areas shown in the maximum inundation extent.

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 Murrumbidgee Junction is outlined in the Environmental Watering section of this EWMP.

Table 3 - Summary of environmental water sources available to Murrumbidgee Junction

Water entitlement	Responsible agency
Murray River unregulated flows Murray River surplus flows	Murray-Darling Basin Authority
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

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

The Murrumbidgee Junction EWMP was first drafted in 2013. This document is a full revision of the 2013 EWMP.

The Mallee Waterway Strategy (2014) identifies Bidgee Lagoons (Narrung Wetlands) (referred to as Bidgee Lagoons) as high priority wetlands in the Mallee CMA region. Additionally, the Strategy identifies a number of specific management activities for Murrumbidgee Junction. These activities are:

- Stock Bidgee Lagoons with priority native species and recreational species (Management activity number B2.1).
- Assess all proposed works areas for presence of Indigenous Cultural Heritage Sites (Management activity number E1.1).
- Implement works established in the Murrumbidgee EWMP (Management activity number C1.1).
- Deliver water as per the Murrumbidgee EWMP (Management activity number C1.2).
- Review the Murrumbidgee EWMP to include recommendations for Wakool Creek and Pile Bend (Management activity number F1.2).
- Maintain depth gauges at Murrumbidgee Junction (Management activity number F1.5).

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

A number of earlier investigations into the Murray River floodplain are relevant to Murrumbidgee Junction and have been considered in the development of this EWMP. These include salinity management plans, flow studies and Land Conservation Council reviews. An investigation into River Red Gum health by the Victorian Environmental Assessment Council (VEAC, 2008) resulted in the Murrumbidgee Junction area being changed from State Park to Regional Park status in 2010.

Additionally, a number of specific studies have been undertaken at Murrumbidgee Junction. A detailed design report: Murrumbidgee Junction Wetland Watering (Alluvium, 2011) presented a regulator design and identified locations for block banks to maintain environmental water or flood flows within the Bidgee Lagoons (Narrung Wetlands). A Cultural Heritage Management Plan (Bell, 2012) was developed and approved by Aboriginal Affairs Victoria for the regulating structures, sandbag levees and access tracks at Bidgee Lagoons (Narrung Wetlands).

Murrumbidgee Junction was also one of the areas included in the Investigation of Water Management Options for the Murray River – Nyah to Robinvale (Ecological Associates, 2006).

DELWP, Parks Victoria and the Mallee CMA have invested significant resources into the area in recent years in both environmental watering in 2005 and complementary on ground works such as track upgrading, pest plant and animal control, and improved signage to decrease recreational pressures on the floodplain.

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.

Murrumbidgee Junction is located between river gauges Wakool Junction (# 414200) and Euston (# 414203) on the Murray River and is downstream of the Murrumbidgee River gauge at D/S Balranald weir (#410130). Ecological Associates (2006) suggest that the hydrology at Murrumbidgee Junction is best described using gauge #414203 (Murray River @ downstream of Euston Weir).

3.1 Wetland hydrology, water management and delivery

Pre-regulation

Prior to river regulation in this reach of the Murray River, the floodplain experienced inundation more frequently and for longer periods. The 2010/2011 floods inundated the entire floodplain within Murrumbidgee Junction, with a peak flood volume of approximately 70,000 ML/day. Under preregulation conditions the floodplain would have been inundated on average 57 times per 100 years compared with 25 times per 100 years post-regulation. The median duration of inundation events has also been reduced by almost half since river regulation.

Ecological Associates (2006) presented wetland and floodplain inundation thresholds for Murrumbidgee Junction using RiMFIM and MWWG database modelled data. For Bidgee Lagoons (Narrung Wetlands) and Wakool Creek the inundation thresholds were inconsistent between the two data sources. Local knowledge has identified that the inundation threshold for Bidgee Lagoons (Narrung Wetlands) is 25,000 ML/day. The inundation threshold for Wakool Creek is a knowledge gap, the models estimate it to be between 30,000 ML/day and 60,700 ML/day. Under pre-regulation conditions Bidgee Lagoons (Narrung Wetlands) would have been inundated on average 97 times per 100 years compared with 73 times per 100 years postregulation. The median duration of inundation events has also been reduced from 183 days to 100 days since river regulation. The median event duration for Wakool Creek, with an inundation threshold of 30,000 ML/day would have been 162 days, compared to 91 days with an inundation threshold of 60,700 ML/day.

Prior to river regulation, the wetlands would have been semi-permanent and the benches fringing the wetland would have been inundated in most years for over four months (Alluvium, 2011). *Bidgee Lagoons (Narrung Wetlands)*

The three large deep billabongs which form Bidgee Lagoons (Narrung Wetlands) are linked by a distinct creek line. As Murray River levels rise, water initially fills the most downstream of the three wetlands via a low effluent, which is connected to the Murray River at chainage 1240.5. Water spills from the first billabong to the next. At the same river level, water spills into the upstream billabong at chainage 1243.5, allowing water to flow through the system (P. Goldring pers. comm. cited in Ecological Associates 2006). The wetlands are deep and expected to hold water for 18 months (P. Goldring pers. comm. cited in Ecological Associates 2006).

Wakool Creek

Wakool Creek follows the landward perimeter of the floodplain. There is little information on the flow behaviour of the creek. Ecological Associates (2006) suggest that the creek fills initially from downstream and as rivers levels rise water spreads to a natural high point in the channel. It is estimated the Wakool Creek will begin to flow from the upstream end at this same river level and flow through will occur. The upstream section of Wakool Creek retains water following flood recession due to the high point in the channel.

Post-regulation

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 4.

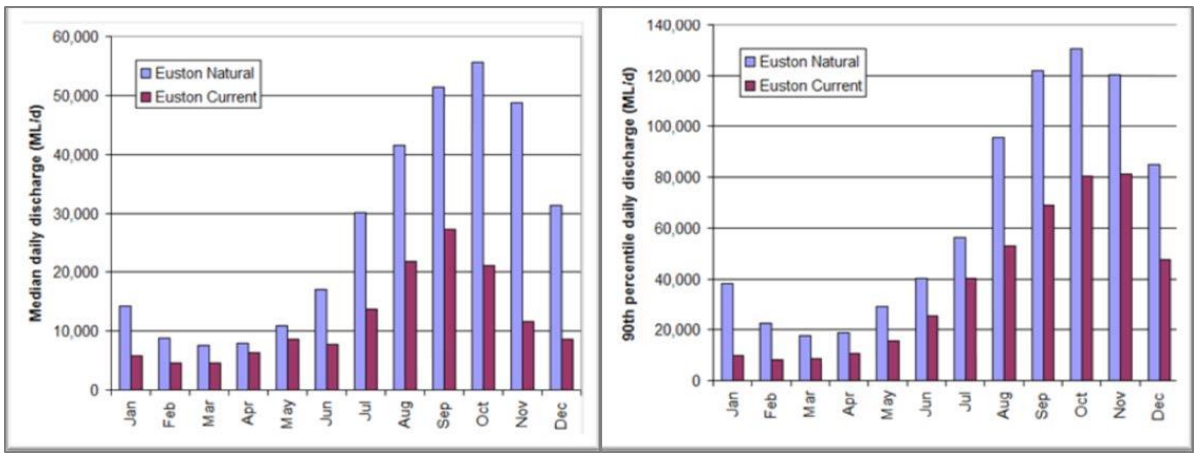


Figure 4 - Distribution of median flows and 90th per centile flows for each month in the Murray River through Euston Weir for pre-regulated and regulated (current) conditions (Ecological Associates, 2006).

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).

The floodplain at Murrumbidgee Junction is inundated in only 22 per cent of years, compared to 55 per cent of years under pre-regulation conditions. Under post-regulation conditions the Bidgee Lagoons (Narrung Wetlands) frequently dry out and the inundation threshold is met in only 68 per cent of years compared to 96 per cent of years under pre-regulation conditions.

Unlike many other wetlands on the Murray floodplain, there are no significant structures, such as dams and levees, impacting the hydrology of the Murrumbidgee Junction floodplain and wetlands. The access tracks may have minor impacts on the hydrology of floodplain.

Environmental watering

Environmental watering was provided to the Bidgee Lagoons (Narrung Wetlands) in 2005 and 2006; details are presented in Table 5. The water was pumped onto the floodplain using temporary earth banks and mobile pumps. The volume required to water Bidgee Lagoons (Narrung Wetlands) in 2005 was significantly higher due to losses associated with watering a wetland that had been dry for a prolonged period. This should be considered for future watering events at Murrumbidgee Junction.

Table 5 - A summary of environmental watering and natural flows at Murrumbidgee Junction

Water year	Waterbody	Time of inflow	Inflow source	Source volume (ML)	Total volume (ML)	Area (ha) inundated
2005	Bidgee Lagoons	Spring	Surplus flows	887	1019	100
	Bidgee Lagoons		Bulk entitlement	132		
2006	Bidgee Lagoons	Autumn	Bulk entitlement	640	640	100
2010/11	Bidgee Lagoons and Wakool Creek	Spring, Summer and Autumn	Natural flows	0	0	Full
2011	Bidgee Lagoons	Spring	Natural flows	0	0	Partial
2012	Bidgee Lagoons	Spring	Natural flows	0	0	Full
2012	Wakool Creek	Spring	Natural flows	0	0	Partial
2016	Bidgee Lagoons and Wakool Creek	Spring and Summer	Natural flows	0	0	Full

This environmental watering 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. The watering event filled the Bidgee Lagoons (Narrung Wetlands) and inundated the adjacent riparian zone. 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.

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 the system.

4 Water dependent values

4.1 Environmental values

Wetlands and waterways on the floodplain are a vital component of the landscape and support a vast array of flora and fauna which may vary greatly 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.

Murrumbidgee Junction 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.

The availability of flora and fauna data for the site is limited. While data from the Victorian Biodiversity Atlas (VBA) (DELWP, 2015) and previous site investigations (Ecological Associates, 2006) have been referenced, it is recommended that flora and fauna surveys are undertaken at the site to improve knowledge of the site's ecological values.

Listings and significance

Fauna

Thirty one native vertebrate fauna species have been recorded at Murrumbidgee Junction. Of special interest and management responsibility are the seven water dependent fauna species listed in legislation, agreements or conventions.

Murrumbidgee Junction supports species listed under the CAMBA, the Commonwealth *EPBC Act*, Victoria's *FFG Act*, and the Advisory List of Threatened Fauna in Victoria (Table 6).

Despite only a limited number of listed fauna being identified in VBA records, 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 Murrumbidgee Junction

Common name	Scientific name	Type	International agreements	EPBC status	FFG Status	VROT advisory list status
Brown Treecreeper (south-eastern ssp.)*	*Climacteris picumnus victoriae*	B	-	-	-	NT
Carpet Python*	*Morelia spilota metcalfei*	R	-	-	L	EN
Golden Perch	*Macquaria ambigua*	F	-	-	-	NT
Major Mitchell's Cockatoo*	*Lophocroa leadbeateri*	B	-	-	-	V
Murray Cod	*Maccullochella peelii*	F	-	VU	L	V

Regent Parrot*	*Polytelis anthopeplus monarchoides*	B	-	VU	L	V
White-bellied SeaEagle	*Haliaeetus leucogaster*	B	CAMBA	-	L	V

Legend:

Lifeform type: Bird, Fish, Invertebrate, Mammal

Convention: China-Australia Migratory Bird Agreement (CAMBA)

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

FFG status: Listed as threatened, Nominated, Delisted, Never Listed, Ineligible for listing VROT advisory list status: presumed Extinct, Regionally Extinct, Extinct in the Wild, CRitically endangered, ENdangered, Vulnerable, Rare, Near Threatened, Data Deficient, Poorly Known, Not Listed

*Species are included as water dependent due to habitat requirements

Of the seven listed species at the site, four are considered indirectly water dependent due to habitat requirements (e.g. dependent on nesting hollows in riparian trees) and the other three are directly dependent on water due to food, shelter or breeding requirements.

Indirectly water dependent birds include the Regent Parrot (*Polytelis anthopeplus monarchoides*), Major Mitchell's Cockatoo (*Lophocroa leadbeateri*), and Brown Treecreeper (*Climacteris picumnus victoriae*) which rely on the hollows provided by River Red Gum (Figure 5).

The Regent Parrot is listed as nationally vulnerable under the EPBC Act, with estimates of only 2,900 birds left in the wild. This species has quite specific habitat requirements. It breeds almost exclusively in River Red Gum (*Eucalyptus camaldulensis*) forest and woodland, typically in large, old and healthy hollow-bearing trees close to water. They require trees that are a minimum of 160 years old (BakerGabb and Hurley, 2011). However, Regent Parrots have also been known to breed in Black Box
(*Eucalyptus largiflorens*). They mostly feed in large blocks of intact Mallee woodlands usually within 5-10km (maximum 20km) of nest sites, but also consume flower buds of River Red Gum, Black Box and Buloke (*Allocasuarina leuhmanii*) (Baker-Gabb and Hurley, 2011). Regent Parrots are reluctant to fly through open areas and require corridors of vegetation between nesting and foraging sites.

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, 2003b).

The Narrung area and surrounds have been identified as having a cluster of Carpet Python (*Morelia spilota metcalfei*) records and moderate to high quality habitat for the species (Robertson and Hurley, 2001). 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 sites (Robertson and Hurley, 2001; DSE, 2003a)

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).

Figure 5 - Mature River Red Gum at Murrumbidgee Junction may provide shelter and nesting habitat for species such as White-bellied Sea-eagle, Regent Parrot, Major Mitchell's Cockatoo and Carpet Python (Sept 2015)

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) and may take advantage of Wakool Creek and Bidgee Lagoons (Narrung Wetlands) during inundation. Fallen logs and woody debris are important habitat for the Golden Perch (Rogers and Ralph, 2011). 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).

Vegetation communities

Murrumbidgee Junction is positioned at the edge of the Murray Fans bioregion, with a small portion of the target area (raised dunes to the west of the site) falling within the Murray Mallee bioregion. Twelve EVCs and one EVC complex are modelled as present in the Murrumbidgee Junction target area.

Table 7 provides a list of the EVCs modelled as present, along with their bioregional conservation status, Figure 6 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 Murrumbidgee Junction target area

EVC no.	EVC name	Area modelled as present within target area (ha)	Bioregional Conservation Status	
			Murray Fans	Murray Mallee
810	Floodway Pond Herbland	28.789	Depleted	n/a
200	Shallow Freshwater Marsh	24.950	Vulnerable	n/a
808	Lignum Shrubland	18.543	Vulnerable	Least Concern
809	Floodplain Grassy Wetland	16.548	Endangered	n/a
818	Shrubby Riverine Woodland	14.360	Least Concern	n/a
-	Bare Rock/Ground	9.836	-	-
823	Lignum Swampy Woodland	3.605	Vulnerable	n/a
103	Riverine Chenopod Woodland	3.141	Endangered	n/a
811	Grassy Riverine Forest / Floodway Pond Herbland Complex	2.502	-	-
824	Woorinen Mallee	0.081	Vulnerable	Vulnerable
106	Grassy Riverine Forest	0.030	Depleted	n/a
97	Semi-arid Woodland	0.006	Vulnerable	n/a
86	Woorinen Sands Mallee	0.003	Depleted	Depleted

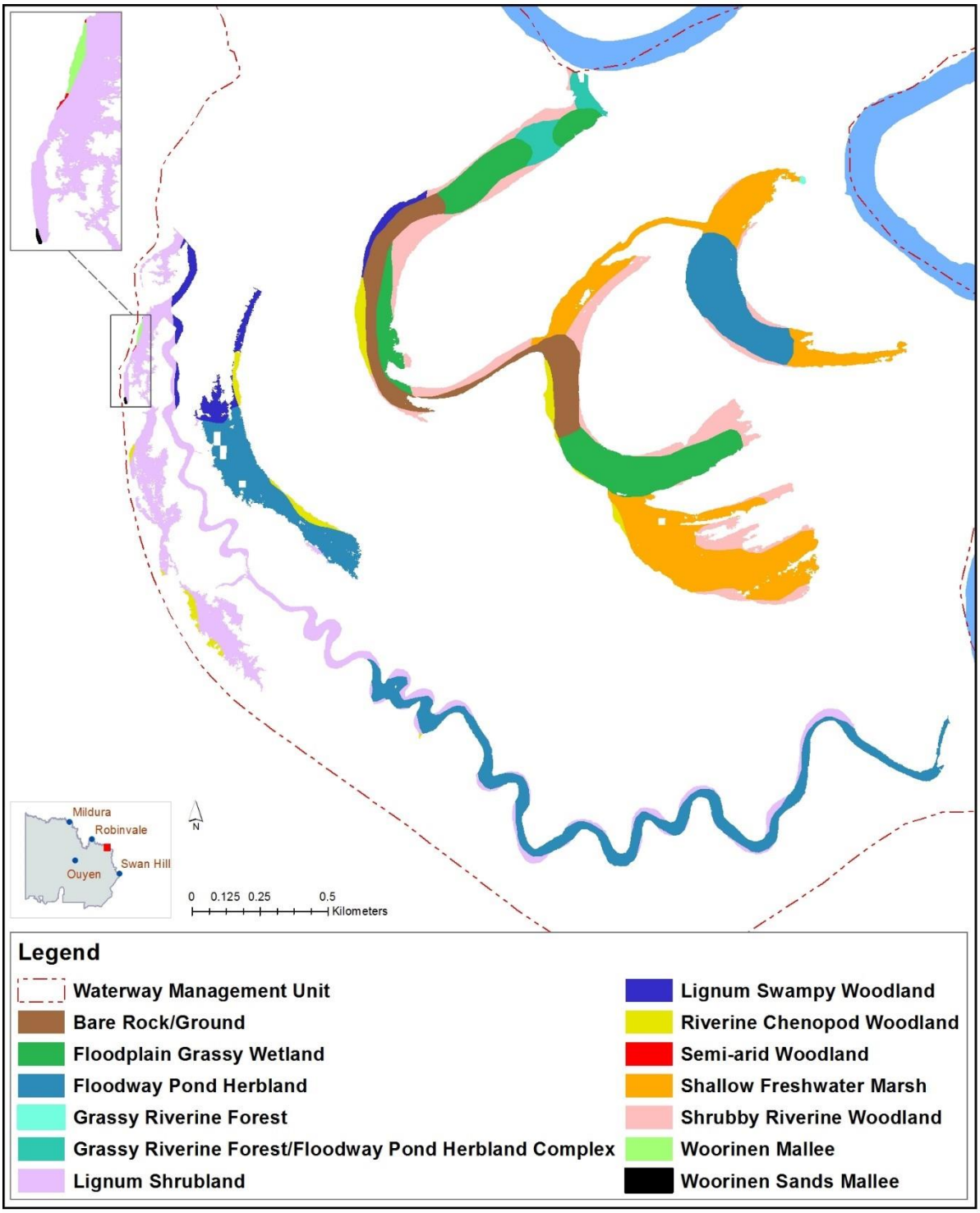


Figure 6 – Ecological Vegetation Classes present in the Murrumbidgee Junction target area Floodway Pond Herbland (EVC 810) is found along the floors of ponds and drainage lines on floodplains with a regular wetting and drying cycle. It is a low herbland (<3m tall) comprised of predominantly ephemeral species with occasional emergents (DSE, 2005). At Murrumbidgee Junction it is located within the Bidgee Lagoons (Narrung Wetlands), associated with Shallow Freshwater Marsh (EVC 200), but in areas with deeper water when inundated. It is also present in Wakool Creek, adjacent to areas of Lignum Swampy Woodland (EVC 823) (Figure 7).

When inundated, the endangered EVC Floodplain Grassy Wetland (EVC 809) is comprised of an assemblage of floating aquatic grasses (which persist to some extent during drier periods). It is found in temporary shallow lakes in flood-prone riverine areas or as a narrow band around floodway ponds. It is generally treeless but may have scattered mature River Red Gum (or thickets of saplings if it has had recent access to water). Floodplain Grassy Wetland is present in Bidgee Lagoons (Narrung Wetlands) in association with the Grassy Riverine Forest / Floodway Pond Herbland Complex (EVC 811) (Figure
8).

Figure 7 - Drainage lines will support a mix of aquatic and ephemeral herbs and grasses during and after inundation (dry phase shown, Sept 2015)

Figure 8 - Grassy Riverine Forest is present along the floodplains and channel connecting Bidgee Lagoons (Narrung Wetlands) to the Murray River (Sept 2015)

Shrubby Riverine Woodland (EVC 818) and Riverine Chenopod Woodland (EVC 103) are found along the higher edges of the Bidgee Lagoons (Narrung Wetlands). 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. Riverine Chenopod Woodland is also found in association with Lignum Shrubland (EVC 808) and Lignum Swampy Woodland near Wakool Creek. Riverine Chenopod Woodland has a diverse shrubby and grassy understorey and is subject to only extremely infrequent incidental shallow flooding from major events (Figure 9).

Black Box Woodlands are particularly important to the Regent Parrot which has been recorded using Black Box hollows for breeding (Baker-Gabb and Hurley, 2011) and the Brown Treecreeper (Cheal, Lucas and Macaulay, 2011) which has been recorded at this site.

Figure 9 – Black Box Woodland on an elevated terrace adjacent to the Bidgee Lagoons (Narrung Wetlands) (Sept 2015) The lignum dominated Lignum Shrubland and Lignum Swampy Woodland are present where flows break out of Wakool Creek into intermittently inundated shallow floodplain depressions. These EVCs have an overstorey of Black Box and River Red Gum, an understorey dominated by lignum, and a ground layer of obligate wetland flora which can persist (even as dormant) over dry periods (DSE, 2005). When flooded these areas can provide nesting habitat for platform building birds as well as productive fish habitat (Ecological Associates, 2006). Tangled Lignum (*Duma florulenta)* has particular ecological value as waterbird breeding habitat (Rogers and Ralph, 2011) making it especially significant at this site. Wetland birds that breed over water, such as Egrets, use flooded Lignum Shrubland (Ecological Associates, 2007) for nesting and other waterbirds use lignum for nesting (Rogers and Ralph, 2011).

In elevated positions on the dunes to the west of Murrumbidgee Junction, where flooding and groundwater influences are minimal or absent, are areas of Woorinen Mallee (EVC 824), Woorinen Sands Mallee (EVC 86) and Semi-arid Woodland (EVC 97).

Flora

One hundred and thirty eight native flora species have been recorded at Murrumbidgee Junction (a full list of flora can be found in Appendix 3). Of these, eight are listed under the FFG Act and/or the Advisory List of Rare of Threatened Flora in Victoria, and three are listed as water dependent as they are found around lakes, water courses or on floodplains (Table 8).

Table 8 - Listed water dependent flora recorded at Murrumbidgee Junction

Common name	Scientific name	Water dependent	FFG Act status	VROT advisory list status
Bush Minuria	*Minuria cunninghamii*	-	-	Rare
Coral Saltbush	*Atriplex papillata*	-	-	Rare
Cotton Sneezeweed	*Centipeda nidiformis*	yes	-	Rare
Doubah	*Marsdenia australis*	-	-	Vulnerable
Dwarf Swainson-pea	*Swainsona phacoides*	-	Listed	Endangered
Goat Head	*Malacocera tricornis*	-	-	Rare
Grey Scurf-pea	*Cullen discolor*	-	Listed	Endangered
Native Couch	*Cynodon dactylon var. pulchellus*	-	-	Poorly known
Riverina Bitter-cress	*Cardamine moirensis*	yes	-	Rare
Spreading Emu-bush	*Eremophila divaricata subsp. divaricata*	-	-	Rare
Squat Picris	*Picris squarrosa*	yes	-	Rare

Other fauna

Fish

Flathead Gudgeon (*Philypnodon gradiceps*) and Dwarf Flat-headed Gudgeon (*Philypnodon macrostomus*) have been found at Bidgee Lagoons (Narrung Wetlands) during previous inundation events. Gudgeon species are wetland opportunists, preferring slow-flowing or still waters with a muddy substrate, woody debris and aquatic vegetation. Their diet includes crustaceans, aquatic insects, tadpoles and small fish (Lintermans, 2007). Bidgee Lagoons (Narrung Wetlands) and Wakool Creek could provide excellent habitat for small native fish species when inundated.

Wetland depletion and rarity

Victoria's wetlands have been mapped and classified in a database known as the 'Wetland 1994' layer (full title: Victorian Wetland Environments and Extent - up to 1994). At the same time, an attempt was made to categorise and map wetland areas occupied prior to European settlement. This is known as the 'Wetland Pre-European (1788)' layer (full title: Wetlands Extent for Victoria Prior to European Settlement – Deduced).

It has been possible to determine the depletion of wetland types across the state between the 1788 and 1994 wetland layers. Comparison between the wetland layers has demonstrated the impact of European settlement and development on Victorian wetlands.

Murrumbidgee Junction contains three wetland types under the 1994 classification, two of which (Deep Freshwater Marsh and Freshwater Meadow) are present within the target area.

A large proportion of these wetland types have been lost in Victoria. Forty three per cent of Freshwater Meadow has been lost across the state (80% in the Mallee CMA region) and seventy per cent of Deep Freshwater Marsh (45% in the Mallee CMA region) (Table 9) (DNRE, 1997).

Table 9 - 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	Percentage change in wetland area from 1788 to 1994		
			Change in Victoria	Change in Mallee CMA	Murray Fans bioregion
Deep Freshwater Marsh	Bidgee Lagoons (Narrung Wetlands)	30.4 ha	-70%	-45%	-6%
Freshwater Meadow	Wakool Creek	28.05 ha	-45%	-80%	-63%

As identified earlier, the Current Wetlands layer has combined the billabongs in Bidgee Lagoons (Narrung Wetlands) into one single wetland, and has listed the wetland type as unknown.

Ecosystem functions

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

Four key broad ecosystem functions have been identified for the Murrumbidgee Junction 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

The combination of Lignum Shrublands and the wetland woodland mosaic provide a great diversity of feeding, breeding and nursery sites for native water-dependent biota.

The mature River Red Gum at this site provide essential habitat for listed species including Carpet Python and Regent Parrot. 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 will promote nutrient and carbon cycling and return organic material to the river for further processing (Robertston, Bacon and Heagney, 2001).

Diversity of habitat for feeding, breeding and nursery

Seasonal fluctuations in the water levels increase the availability of specific habitat niches for feeding, breeding and nursery areas. The higher water levels proposed in spring and summer will provide a

source of food, refuge from predators and nesting sites and materials (Kingsford and Norman, 2002). Receding water levels will expose mudflats required by small waders (Roshier, Robertston and Kingsford, 2002).

Inundation of the wetlands and woodlands will provide roosting and nesting habitat for species such as darters (Vestjen, 1975) and cormorants (Loyn, Lumsden and Ward, 2002), while the increase in macrophyte diversity and abundance will increase habitat values for waterbirds and small fish. Flooded Lignum Shrubland is important for waterbird nesting.

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

Wetland inundation will transport nutrients and carbon into the water column, which will become available for consumption by bacteria, algae, macrophytes and macroinvertebrates.

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).

Fluctuations in water levels allow exposure of substrates such as large wood and plant stems through a drying cycle, supporting a mosaic of biofilm species that offer a range of food resources for macroinvertebrates and fish (SKM, 2009).

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 density of identified indigenous cultural heritage sites are located around or close to areas of freshwater sources.

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

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

The Bidgee Lagoons (Narrung Wetlands) are an important cultural site for the local indigenous people. A total of 1,088 Aboriginal places have been registered within the geographic region including scarred trees (871), earth features (78), shell deposits (75), artefact scatters (43), burial/human remains (19) and two historical places (Bell, 2012). Predictive models expect Aboriginal places to be situated close to ephemeral or permanent water sources and the Murray River is known to be well-utilised by Aboriginal people.

During his exploration of the Narrung area during 1836, Major Thomas Mitchell documented early encounters with Aboriginal people. Maps indicating locations of tribes were produced for the area from 1904, with subsequent maps displaying discrepancies with tribal boundaries. A search of the Victorian Aboriginal Heritage Register identified 29 archaeological reports in the geographic region, with the majority associated with irrigation, construction and housing developments (Bell, 2012).

Two Native Title Claimant groups cover the area, the Robinvale Aboriginal Community (RAC) and Latji Latji Peoples (Latji Latji). There is currently no Registered Aboriginal Party (RAP) appointed, however the Tati Tati Aboriginal Corporation in the area has applied for RAP status in the past (Bell, 2012).

European heritage sites reflect the pioneering history of the area and Narrung was visited by Captain Charles Sturt (1830) and Major Thomas Mitchell (1836). Mitchell set up a camp site, known as Passage Camp on his third expedition to the interior. Drovers commenced overlanding stock via the area shortly after and Narong, Narrung or Neroney pastoral run was gazetted in 1848. Within ten years of Mitchell's third expedition, the area was taken up by squatting runs of cattle and sheep. The large squatting and pastoral runs were subdivided in the 1850-1870s into agricultural allotments (Bell, 2012).

4.3 Recreation

The region is popular for swimming, camping, fishing, boating, four wheel driving, picnicking, and walking. The Murrumbidgee Junction forms part of the Major Mitchell Trail. Passage Camp provides fire places for campers and a walking trail to the old Narrung town site (Discover the Murray River website). VEAC (2008) recommended that camping and campfires continue to be permitted in the area.

4.4 Economic values

Murrumbidgee Junction has been used for grazing, and domestic firewood collection in the past. The surrounding areas are used for irrigated horticulture and dryland cropping. The site is close to the township of Boundary Bend, which boasts thriving olive and almond growing and associated industries. The town and surrounding area has a population of 182.

4.5 Significance

Murrumbidgee Junction supports significant environmental and indigenous cultural heritage values. Bidgee Lagoons (Narrung Wetlands) are significant as they are semi-permanent freshwater wetlands, supporting a broad range of water dependent flora and fauna within a woodland forest-wetland mosaic. Mature River Red Gum trees are found throughout Murrumbidgee Junction. Significant species dependent on mature River Red Gum have been recorded at the site including Carpet Python, Regent Parrot, Major Mitchell's Cockatoo, White-bellied Sea-eagle and Brown Tree-creeper. Some of the mature

River Red Gum are scar trees and have significant indigenous cultural heritage values. Wakool Creek could provide habitat for a variety of waterbirds through the provision of roosting and nesting habitat in the Lignum Shrubland. Wakool Creek and Bidgee Lagoons (Narrung Wetlands) could also support smallbodied and juvenile large-bodied native fish when inundated.

5 Ecological condition and threats

5.1 Current condition

Index of Wetland Condition assessments have not been undertaken for wetlands within the target area. The condition information described below is based on brief field observations and limited existing literature.

Wakool Creek was subject to Index of Stream Condition assessments in 1999, 2004 and 2010. The 2010 assessment found Wakool Creek to be in poor condition (DELWP, 2015b). Only three of the five sub-indices were measured: hydrology (2/10), physical form (6/10) and streamside zone (6/10). A score of ten for a sub-index indicates excellent condition.

Field inspections undertaken during September 2015 found the Bidgee Lagoons (Narrung Wetlands) to be in a dry phase. Evidence of a decline in health was visible in River Red Gums within, or adjacent to, the wetlands. River Red Gum saplings that are likely to have been recruited during the 2005/2006 environmental watering event were in particularly poor health. Abundant leaf litter and structural habitat was present within the channels however understorey diversity appeared very low.

Figure 10 - Bidgee Lagoons (Narrung Wetlands) showing young River Red Gum in poor health and older fringing River Red

Gum showing some foliage loss (Sept 2015)

Figure 11 - Bidgee Lagoons (Narrung Wetlands) showing abundant leaf litter and River Red Gum saplings in poor health (Sept 2015)

Figure 12 - Bidgee Lagoons (Narrung Wetlands) (Sept 2015)

Figure 13 - Floodplain channel linking Bidgee Lagoons (Narrung Wetlands) to the Murray River showing abundant leaf litter and large wood (source: A. Edwards 26/07/2011 in (Bell, 2012)

5.2 Condition trajectory

If the current water regime at the site continues, significant ecological losses may occur.

While some improvement in River Red Gum canopy health occurred as a result of the watering event in 2005/2006, further watering is required to ensure that the mature River Red Gum are protected. Additionally, structural diversity will continue to decline within the wetlands if they remain dry.

It is evident that the watering in 2005/2006 led to regeneration of River Red Gum within the wetlands however, many of these trees have subsequently died or are in serious decline. It is important to ensure that regeneration of River Red Gum occurs and that some of these trees reach maturity.

Many of the mature River Red Gum that line the floodplain channels into Bidgee Lagoons (Narrung Wetlands) and surround Bidgee Lagoons (Narrung Wetlands) have indigenous cultural significance. Maintenance of these trees for indigenous cultural heritage purposes and to protect habitat for mature River Red Gum dependent species, such as Carpet Python and Regent Parrot, is important within the target area.

Overall the site retains some significant values and vegetation health is relatively good. It is important to ensure that the essential ecosystem functions are supported in years with high to average rainfall and flow, to enable ecosystem resilience during periods of successive dry years, such as during drought. Improvements to the water regime as outlined in this EWMP will build this resilience.

5.3 Water related threats

Water related threats occurring within the target area and identified through the Aquatic Value Identification and Risk Assessment (AVIRA) database (identified by a score of 4 or 5) are:

- Invasive fauna (aquatic) – 5
- Changed water regime – 5 – Bidgee Lagoons (Narrung Wetlands)
- Increase in Low Flow Magnitude (4) – Wakool Creek
- Loss of Instream Habitat (Large wood) – Wakool Creek

Changed water regime

As discussed in the hydrology section of this EWMP, the hydrology of the target area has been greatly impacted by the regulation of the Murray River. Bidgee Lagoons (Narrung Wetlands) 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.

Increase in Low Flow Magnitude

As outlined in the condition section of this EWMP, Wakool Creek received a score of one for the hydrology sub-index of the Index of Stream Condition. The hydrology sub-index for rivers and creeks is calculated using values from the flow stress ranking project, which evaluated changes to each of the flow components of the system. AVIRA noted that changes to low flows within Wakool Creek have been the most significant impact on the hydrology within the creek.

Invasive fauna (aquatic)

Common Carp would be prevalent in Bidgee Lagoons (Narrung Wetlands) and Wakool Creek when inundated. 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 as well as having a detrimental effect on water quality (Mallee CMA, 2003).

Loss of instream habitat (large wood)

Woody debris (large wood) provides valuable habitat for fish, birds and other aquatic fauna. For example:

- Fish use woody debris as sites to spawn and rear juveniles.
- Water birds use emergent woody debris as sites for roosting, preening and nesting.

The 2010 ISC assessment measured the Loss of Instream Habitat (Large wood) indicator by assessing:

- The density of instream wood.
- The location of large wood (stream edges, mid-stream etc.).
- The origin of large wood (indigenous vs exotic).

Reduction of overbank flows within Wakool Creek, along with the prolonged dry conditions experienced with the millennium drought, may have led to a reduction in the recruitment of large wood within Wakool Creek. It is possible that fire wood collection activities may have reduced the amount of large wood available within Wakool Creek and on the adjacent floodplain.

6 Management objectives

6.1 Management goal

The management goal for the Murrumbidgee Junction EWMP is:

To provide a water regime for the Bidgee Lagoons (Narrung Wetlands) and Wakool Creek with a more natural frequency and duration that will maintain and promote the health of the mature River Red Gum and encourage regeneration and ecosystem productivity within the Murrumbidgee Junction target area.

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 Murrumbidgee Junction are to:

- Maintain a healthy and productive wetland woodland mosaic (particularly EVCs 809, 810,818, 200).
- Maintain mature River Red Gum which provide nesting, roosting and structural habitat for Carpet Python, White-bellied Sea-eagle, Regent Parrot and Major Mitchell's Cockatoo.
- Promote a healthy and productive Lignum Shrubland (EVC 808) providing habitat for waterbird nesting and roosting.
- Sustain resident populations of small-bodied native fish and opportunistic use by large-bodied native fish through maintenance of permanent pool habitat.
- Promote seasonal emergent and semi-emergent macrophytes.

Table 10 - Ecological objectives for Murrumbidgee Junction

Ecological objective	Justification	Wetland area

Maintain a healthy and productive wetland woodland mosaic (particularly EVCs 809, 810,818, 200).	Ecological Associates (2006) highlight wetland woodland mosaics as areas of particular conservation significance. They support the flora and fauna of wetland and woodland floodplain components, with additional habitat features. 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.	Bidgee Lagoons (Narrung Wetlands)
Maintain mature River Red Gum which provide nesting, roosting and structural habitat for Carpet Python, White-bellied Sea-eagle, Regent Parrot and Major Mitchell's Cockatoo.	River Red Gum are the structural dominant species within Bidgee Lagoons (Narrung Wetlands). Their health is essential to maintaining a functioning wetland and floodplain channel system. Mature River Red Gum provide essential habitat, such as nesting hollows and roosting sites, for significant species found within the target area including Carpet Python, White-bellied Seaeagle, Regent Parrot and Major Mitchell's Cockatoo.	Bidgee Lagoons (Narrung Wetlands)
Promote a healthy and productive Lignum Shrubland (EVC 808) providing habitat for waterbird nesting and roosting.	Lignum flora communities are important habitat and feeding opportunities for fauna species within the target area. They are particularly important for waterbird roosting and nesting (Ecological Associates, 2006). Tangled Lignum found at this site has particular ecological value as waterbird breeding habitat. Healthy lignum can also provide shelter and feeding sites for Carpet Python and Woodland birds such as Brown Treecreeper.	Wakool Creek
Sustain resident populations of small-bodied native fish and opportunistic use by large-bodied native fish through maintenance of permanent pool habitat.	As well as the intrinsic value of native fish presence, smallbodied native fish also provide an important food source for piscivorous waterbirds and some large-bodied native fish species.	Bidgee Lagoons (Narrung Wetlands)
Promote seasonal emergent and semiemergent macrophytes.	Macrophytes provide habitat for a range of species including shelter from predators, nesting sites and a source of organic matter.	Bidgee Lagoons (Narrung Wetlands)

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 Table 11 and described below.

River Red Gum are the structural dominant species within and along the fringes of Narrung Wetlands. River Red Gum woodlands require flooding every two to four years with durations of two to four months. Flood events may differ and a variation in ponding duration around the mean requirement for this species is encouraged. Although the timing of flooding is not vital for River Red Gum, spring-summer flooding encourages greater growth. Timing is however important for understory plant communities. The critical interval for River Red Gum woodland inundation is five to seven years to prevent deterioration of tree condition (Roberts and Marston, 2011).

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

Emergent and semi-emergent macrophytes are likely to be supported in Bidgee Lagoons (Narrung Wetlands) and would provide essential shelter for small-bodied native fish and frogs, nesting habitat for birds, and a source of organic matter. Flood requirements 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.

Table 11 - Hydrological objectives for Murrumbidgee Junction

Ecological Objectives	Water management area	Hydrological Objectives								Preferred timing of inflows	Target supply level (mAHD)	Volume to fill to TSL (ML)	Volume to maintain at TSL (ML)	Total volume per event (ML)
		Mean frequency of events (No. per 10 years)			Tolerable interval between events (years)		Duration of ponding (months)							
		Min.	Opt.	Max.	Min.	Max.	Min.	Opt.	Max					
Maintain a healthy and productive wetland woodland mosaic (particularly EVCs 809, 810,818, 200). Maintain mature River Red Gum which provide nesting, roosting and structural habitat for Carpet Python, White-bellied Sea-eagle, Regent Parrot and Major Mitchell's Cockatoo.*	Bidgee Lagoons (Narrung Wetlan	2	3	5	1	7	2	3	4	Spring/ Summer	54.4			
Sustain resident populations of small-bodied native fish and opportunistic use by large-bodied native fish through maintenance of pool habitat	Narrung Wetlands	8	10	10	1	2	12	12	12	N/A	52.1			
Promote seasonal emergent and semi-emergent macrophytes	Narrung Wetlands	2	5	10	0	0	1	6	12	Winter/ Spring	52.5	1,083**	250***	1,333
Promote a healthy and productive Lignum Shrubland (EVC 808) providing habitat for waterbird nesting and roosting.	Wakool Creek	1	3	5	1	10	3	5	7	Spring/ Summer	55.4	201.3**		201.3**

*Objective met by other hydrological objective ** Volume estimated from LiDAR ***Volume estimated from past watering activities

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. An accurate inundation threshold for Wakool Creek is a significant knowledge gap, which should be investigated as a priority.

Optimal watering regime

Bidgee Lagoons (Narrung Wetlands)

Fill Bidgee Lagoons (Narrung Wetlands) to 54.4 mAHD in spring three times in ten years targeting the health and productivity of the River Red Gum dominated wetland woodland mosaic. Ensure water level remains at wetland capacity for three months. Allow water to draw down naturally over the subsequent season allowing exposure of the littoral zone and promotion of aquatic macrophytes. Top up as necessary, to keep water level at 52.1 mAHD to ensure that permanent pool habitat for small-bodied native fish is maintained. *Wakool Creek*

Fill Wakool Creek from the upstream pump site to 55.4 mAHD five times in ten years to promote large lignum shrubs with vigorous canopy capable of supporting waterbird nesting and roosting. Ensure water levels remain at this level for five months, to provide opportunities for waterbirds, such as cormorants and darters to fledge.

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
Murray River levels too low for environmental water pumping to commence	Possible	Moderate	M	Watering regime planned using seasonally adaptive approach. Environmental watering planned appropriately with stakeholders.	L
Water regime significantly enhances habitat for Carp	Likely	Moderate	M	Monitoring of Carp and waterbird populations. Review of inlet and pumping equipment to screen Carp.	L
Sudden reduction in water levels strand native fish	Possible	Moderate	M	Monitor recession rates, manage regulator operations accordingly.	

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
Environmental releases flood access tracks	Possible	Minor	M	Track works associated with regulator and stop bank construction undertaken with appropriate planning. Provide signage about watering event. Engagement plan to be implemented.	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
Flooding of private land	Likely	High	VH	Ensure appropriate monitoring of pumped flows, use LiDAR to estimate inundation levels. Investigate need for remedial works on spoon drain and channel to stop over topping or leakage. Undertake appropriate engagement prior to event and obtain landowners consent.	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

There has been a significant reduction in the frequency of flooding of the Bidgee Lagoons (Narrung Wetlands) and Wakool Creek. Infrastructure is recommended to allow the recommended hydrological objectives to be met. Environmental watering at this site requires pumping from the Murray River and the construction of regulators and stop banks to retain this pumped water for the recommended duration.

The infrastructure used to provide environmental water in 2005/2006 was only temporary and it was removed following the event. Temporary infrastructure is more prone to safety and vandalism risks and this has been considered in the risk assessment.

8.2 Infrastructure or complementary works recommendations

Bidgee Lagoons (Narrung Wetlands)

Ecological Associates (2007) recommended the construction of a permanent regulator across one of the effluents running into Bidgee Lagoons (Narrung Wetlands).

Alluvium was commissioned in 2011 to undertake a detailed design report of the works. The works include the installation of a regulator at the downstream end of the Bidgee Lagoons (Narrung Wetlands) in order to retain water in the wetland. The proposed site for the regulator is on an existing road. It is proposed that the regulator will consist of concrete box culverts set into the existing road, wing walls and aprons. The regulator gates will be segmented stop boards attached to the downstream side of the culvert, and with a removable Carp screen on the upstream side. No power will be required for the operations at the site (Alluvium, 2011).

The design criteria for the regulator included:

- design minimum flow rate of 1.3 m3/s (113 ML/d)
- able to pass flows both ways
- able to cater for flows overtopping the structure above water level 54.8 m AHD
- manual operation
- caters for overshot passage of flows
- caters for vehicular access across the structure
- caters for fish passage into wetlands
- Carp screens to prevent large bodied specimens returning to the Murray River.

The regulator is designed to provide an inundation level of 54.4m AHD. At this level there are two locations where re-entry to the Murray River could occur during environmental watering. The northern block bank would be built using approximately 400 sandbags. The eastern blockbank would be a 0.6m high by 10 metres long earthen block bank (Alluvium, 2011). The location of the eastern blockbank is shown in Figure 14.

Figure 14 - Location of the eastern blockbank. Photo taken from track which will be incorporated into the stopbank (Sept 2015)

The design criteria for the blockbanks were:

- Sandbags to be used to infill the Northern blockbank to avoid impacts on cultural heritage assets.
- Use of the existing access track on the Eastern blockbank.

A temporary pump would operate at 0.6m^3/s to fill the Bidgee Lagoons (Narrung Wetlands) to target inundation level from empty. This would take 21 days.

The location of the proposed infrastructure is shown in Figure 15.

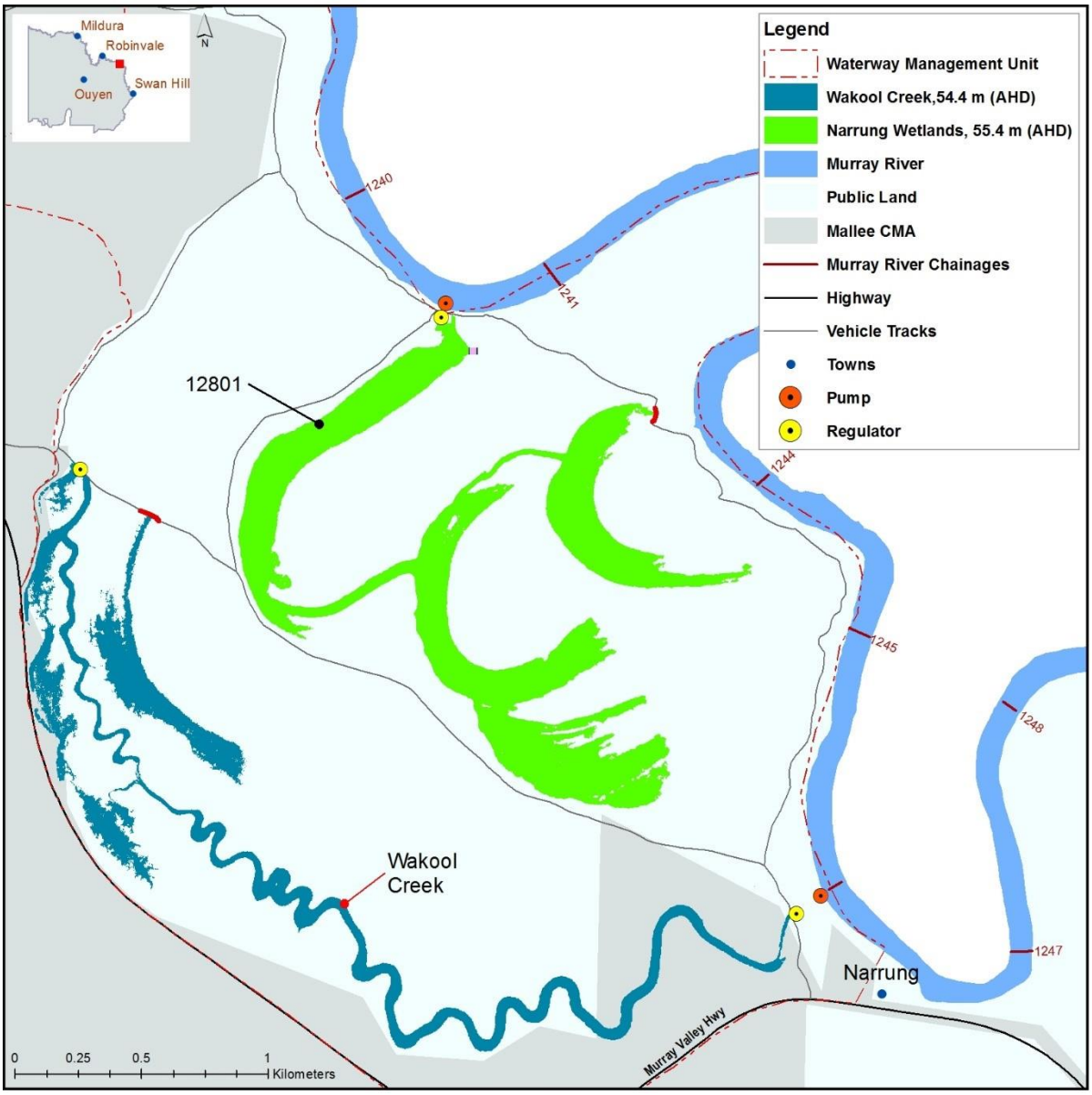


Figure 15 - Proposed infrastructure locations for Bidgee Lagoons (Narrung Wetlands) and Wakool Creek

Wakool Creek

The environmental and hydrological objectives for Wakool Creek can only be achieved with infrastructure. Unlike Bidgee Lagoons (Narrung Wetlands), a detailed design phase has not been completed for infrastructure at Wakool Creek.

Ecological Associates (2006) identified that water could be retained in Wakool Creek by:

- constructing a regulator at the downstream end; and
- lowering the sill in the upstream end of the creek by 0.5 metres for the first 500 metres and constructing a regulator.

Using LiDAR, the proposed location of road raising has been identified and a regulator will be installed so as not to inhibit natural inflows, as shown in Figure 15.

9 Demonstrating outcomes

9.1 Monitoring priorities at the site

The following priorities for monitoring have been identified for the Murrumbidgee Junction 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 within the wetlands.
- Fauna records for Murrumbidgee Junction are very sparse. Monitoring of waterbird and fish use of the target area following environmental watering is required.
- Fauna surveys targeting listed water dependent species that are likely to be at the site and which require mature River Red Gum.

10 Consultation

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

Table 12 - Consultation for development of Murrumbidgee Junction EWMP

Meeting Date	Stakeholders	Details
May 2011	Robinvale Claimant Group Tati Tati representatives (Latji Latji were unable to attend)	Discussion of the proposal and the process of developing a CHMP
Jun 2011	Robinvale Claimant Group Tati Tati representatives Parks Victoria	Site visit, including design consultants and geotechnical testers to discuss the proposed works
Aug 2011	Boundary Bend Community	Overview of environmental plans for the area
Aug 2011	Mallee CMA Technical Advisory Committee	Update on EWMP plans
Dec 2011	Latji Latji Robinvale Aboriginal Community	Site visit to discuss management recommendations for the CHMP
January 2016	Parks Victoria	Discussion about the EWMP updates.
May 2016	Parks Victoria	Plan presentation
June 2016	Murray Lower Darling Rivers Indigenous Nations	Plan presentation
June 2016	Mildura BirdLife	Plan presentation
June 2016	Department of Environment, Land, Water and Planning	Plan presentation

11 Knowledge gaps and recommendations

Detailed design report for Wakool Creek infrastructure

A detailed design report is required to scope the infrastructure requirements for Wakool Creek.

Index of Wetland Condition assessment

Bidgee Lagoons (Narrung Wetlands) should be incorporated into the five-yearly Index of Wetland Condition assessments.

Confirm the inundation threshold levels for Wakool Creek

Ecological Associates (2006) compiled inundation thresholds for wetlands within the study area using several sources of modelled and gauged data. The inundation thresholds for Wakool Creek were inconsistent between the data sources. Confirmation of the correct inundation threshold for Wakool Creek is required.

Flora and fauna present at the site

The flora and fauna records for Murrumbidgee Junction are particularly scarce. Targeted flora and fauna studies, focussing on water dependent species, particularly waterbirds and fish using the site during environmental watering would be useful. This will help to confirm the ecological objectives are appropriate.

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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

Common name	Scientific name	Type	No. of records
Australian Magpie	*Gymnorhina tibicen*	B	1
Australian Raven	*Corvus coronoides*	B	1
Brown Treecreeper (south-eastern ssp.)	*Climacteris picumnus victoriae*	B	1
Carpet Python	*Morelia spilota metcalfei*	R	1
Chestnut-crowned Babbler	*Pomatostomus ruficeps*	B	1
Common Bronzewing	*Phaps chalcoptera*	B	1
Dwarf Flat-headed Gudgeon	*Philypnodon macrostomus*	F	1
European Carp*	*Cyprinus carpio*	F	1
Flathead Gudgeon	*Philypnodon grandiceps*	F	1
Galah	*Eolophus roseicapilla*	B	2
Golden Perch	*Macquaria ambigua*	F	1
Grey Shrike-thrush	*Colluricincla harmonica*	B	1
Laughing Kookaburra	*Dacelo novaeguineae*	B	1
Little Corella	*Cacatua sanguinea*	B	1
Magpie-lark	*Grallina cyanoleuca*	B	1
Major Mitchell's Cockatoo	*Lophocroa leadbeateri*	B	1
Murray Cod	*Maccullochella peelii*	F	1
Noisy Miner	*Manorina melanocephala*	B	1
Pacific Black Duck	*Anas superciliosa*	B	1
Red-capped Robin	*Petroica goodenovii*	B	1
Redfin*	*Perca fluviatilis*	F	1
Red-rumped Parrot	*Psephotus haematonotus*	B	1
Regent Parrot	*Polytelis anthopeplus monarchoides*	B	2
Rufous Whistler	*Pachycephala rufiventris*	B	1
Sacred Kingfisher	*Todiramphus sanctus*	B	1
Striated Pardalote	*Pardalotus striatus*	B	2
Sulphur-crested Cockatoo	*Cacatua galerita*	B	1
Tree Martin	*Petrochelidon nigricans*	B	1
Welcome Swallow	*Petrochelidon neoxena*	B	2
White-bellied Sea-Eagle	*Haliaeetus leucogaster*	B	1
White-necked Heron	*Ardea pacifica*	B	1
White-plumed Honeyeater	*Lichenostomus penicillatus*	B	2
Willie Wagtail	*Rhipidura leucophrys*	B	2

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

Source: (DELWP, 2015; Ecological Associates, 2006)

Appendix 2 – Ecological vegetation classes (EVCs)

EVC no.	EVC name	Bioregional Conservation Status		Description
		Murray Fans	Murray Mallee	
86	Woorinen Sands Mallee	Depleted	Depleted	Mallee shrubland to 7 m tall, typically supporting a hummock grass (Triodia spp.) dominated understorey. This EVC could be considered intermediate between the heavier soil mallee woodlands and the lighter sandy soil mallee vegetation predominant on Lowan (siliceous) sand.
97	Semi-arid Woodland	Vulnerable	Vulnerable	Non-eucalypt woodland or open forest to 12 m tall, of low rainfall areas. Occurs in a range of somewhat elevated positions not subject to flooding or inundation. The surface soils are typically light textured loamy sands or sandy loams.
103	Riverine Chenopod Woodland	Endangered	n/a	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.
200	Shallow Freshwater Marsh	Vulnerable	n/a	Generally, shallow freshwater marshes are no more than half a metre deep and usually dry out in summer. They are usually formed in volcanic flow beds. Large stands of River Red Gum or lignum are often found around shallow freshwater marshes, with reeds, rushes and Cane Grass, or low-growing herbs and sedges, dominating the vegetation.
808	Lignum Shrubland	Vulnerable	Least Concern	Relatively open shrubland of species of divaricate growth form. The ground-layer is typically herbaceous or a turf grassland, rich in annual/ephemeral herbs and small chenopods. Characterised the open and even distribution of relatively small lignum shrubs. Occupies heavy soil plains along Murray River, low-lying areas on higher-level (but still potentially flood-prone) terraces.

809	Floodplain Grassy Wetland	Endangered	n/a	Wetland dominated by floating aquatic grasses (which persist to some extent as turf during drier periods), occurring in the most flood-prone riverine areas. Typically treeless, but sometimes with thickets of saplings or scattered more mature specimens of Eucalyptus camaldulensis. Occupies temporary shallow lakes in the most flood-prone riverine areas, also occurs as a narrow intermediate band around some floodway ponds.
810	Floodway Pond Herbland	Depleted	n/a	Low herbland to < 0.3 m tall with occasional emergent life forms, usually with a high content of ephemeral species. Floors of ponds associated with floodway systems. Typically heavy deeply cracking clay soils. Characteristically smaller wetlands with a more regular flooding and drying cycle in comparison to sites supporting Lake Bed Herbland.
811	Grassy Riverine Forest	Depleted	n/a	Occurs on the floodplain of major rivers, in a slightly elevated position where floods are infrequent, on deposited silts and sands, forming fertile alluvial soils. River Red Gum forest to 25 m tall with a groundlayer dominated by graminoids. Occasional tall shrubs present.
811	Grassy Riverine Forest / Floodway Pond Herbland Complex		n/a	Complex
818	Shrubby Riverine Woodland	Least Concern	n/a	Eucalypt woodland to open forest to 15 m tall of less floodprone (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	Vulnerable	n/a	Understorey dominated by lignum, typically of robust character and relatively dense (at least in patches), in association with a low Eucalypt and/or Acacia woodland to 15 m tall. The ground layer includes a component of obligate wetland flora that is able to persist even if dormant over dry periods.

824	Woorinen Mallee	Vulnerable	Vulnerable	Widespread mallee woodland to 12 m tall, associated with the east-west orientated calcareous dunefields of the Woorinen Formation with a low, open chenopod dominated shrub understorey. A diverse array of sub-shrubs, herbs and grasses are also present. Typically occurs on fine textured red-brown sandy loam and clay loam soils.

Source: (DELWP, 2015a; DSE, 2004, 2005)

Appendix 3 – Flora species list

Common Name	Scientific Name	No. of records
Acorn-fruited Thread-moss	*Gemmabryum pachythecum*	1
Aster-weed*	*Aster subulatus*	1
Austral Bugle	*Ajuga australis*	1
Babbagia	*Osteocarpum acropterum* var. *deminutum*	2
Ball Moss	*Phascum robustum* var. *robustum*	1
Barley-grass*	*Hordeum murinum* s.l.	1
Berry Saltbush	*Atriplex semibaccata*	1
Black Box	*Eucalyptus largiflorens*	4
Black Nightshade*	*Solanum nigrum* s.l.	1
Black Roly-poly	*Sclerolaena muricata*	2
Bluebush	*Maireana* spp.	1
Box Mistletoe	*Amyema miquelii*	2
Burr Daisy	*Calotis* spp.	1
Burr Medic*	*Medicago polymorpha*	1
Bush Minuria	*Minuria cunninghamii*	1
Cape weed*	*Arctotheca calendula*	1
Clay Plantain	*Plantago cunninghamii*	2
Coast Barb-grass*	*Parapholis incurva*	1
Common Blown-grass	*Lachnagrostis filiformis* s.l.	4
Common Heliotrope*	*Heliotropium europaeum*	1
Common Nardoo	*Marsilea drummondii*	3
Common Sneezeweed	*Centipeda cunninghamii*	3
Common Sow-thistle*	*Sonchus oleraceus*	5
Common Spike-sedge	*Eleocharis acuta*	3
Common Wallaby-grass	*Rytidosperma caespitosum*	1
Composite	*Asteraceae* spp.	1

Coral Saltbush	*Atriplex papillata*	1
Cotton Fireweed	*Senecio quadridentatus*	3
Cotton Sneezeweed	*Centipeda nidiformis*	1
Couch	*Cynodon dactylon*	2
Crowned Plantain	*Plantago turrifera*	1
Curly Pocket-moss	*Fissidens megalotis*	1
Dense Crassula	*Crassula colorata*	2
Dissected New Holland Daisy	*Vittadinia dissecta* s.l.	3
Doubah	*Marsdenia australis*	1
Dwarf Swainson-pea	*Swainsona phacoides*	6

Earth Moss	*Bryobartramia novae-valesiae*	1
Earth Moss	*Ephemerum cristatum*	2
Eumong	*Acacia stenophylla*	1
Ferny Cotula*	*Cotula bipinnata*	1
Ferny Small-flower Buttercup	*Ranunculus pumilio* var. *pumilio*	1
Fescue*	*Vulpia* spp.	1
Finger Rush	*Juncus subsecundus*	2
Flannel Cudweed	*Actinobole uliginosum*	1
Flat Spurge	*Euphorbia drummondii* spp. agg.	1
Flat-top Saltbush	*Atriplex lindleyi*	1
Flatweed*	*Hypochaeris radicata*	2
Flaxleaf Fleabane*	*Conyza bonariensis*	1
Fog-fruit*	*Phyla canescens*	2
Fuzzy New Holland Daisy	*Vittadinia cuneata*	1
Goat Head	*Malacocera tricornis*	1
Grassland Wood-sorrel	*Oxalis perennans*	2
Great Brome*	*Bromus diandrus*	2
Grey Box	*Eucalyptus macrocarpa*	1
Grey Scurf-pea	*Cullen discolor*	1
Hairy Burr-daisy	*Calotis hispidula*	1
Hairy Rupture-wort*	*Herniaria cinerea*	1
Hedge Saltbush	*Rhagodia spinescens*	2
Jagged Bitter-cress	*Rorippa laciniata*	1
Jersey Cudweed	*Helichrysum luteoalbum*	2
Leek Lily	*Bulbine semibarbata*	1

Lesser Joyweed	*Alternanthera denticulata* s.s.	2
Little Medic*	*Medicago minima*	1
London Rocket*	*Sisymbrium irio*	1
Love Grass	*Eragrostis* spp.	1
Marsh Fox-tail*	*Alopecurus geniculatus*	1
Mediterranean Catchfly*	*Silene nocturna*	1
Mediterranean Turnip*	*Brassica tournefortii*	1
Mousetail	*Myosurus australis*	1
Narrow-leaf Dock	*Rumex tenax*	1
Narrow-leaf Nardoo	*Marsilea costulifera*	1
Native Couch	*Cynodon dactylon* var. *pulchellus*	1
New Holland Daisy	*Vittadinia* spp.	1
Nightshade	*Solanum* spp.	2
Nitre Goosefoot	*Chenopodium nitrariaceum*	3

Nitre-bush	*Nitraria billardierei*	2
Nodding Saltbush	*Einadia nutans*	3
Northern Barley-grass*	*Hordeum glaucum*	1
Pale Beauty-heads	*Calocephalus sonderi*	3
Paradoxical Canary-grass*	*Phalaris paradoxa*	1
Pineapple Moss	*Gigaspermum repens*	1
Poached-eggs Daisy	*Polycalymma stuartii*	1
Poison Pratia	*Lobelia concolor*	1
Prickly Lettuce*	*Lactuca serriola*	2
Prickly pear*	*Opuntia* spp.	4
Prickly Saltwort	*Salsola tragus*	1
Prickly Saltwort	*Salsola tragus* subsp. *tragus*	1
Rat's-tail Fescue*	*Vulpia myuros*	2
Rat-tail Couch	*Sporobolus mitchellii*	1
Red Bird's-foot Trefoil	*Lotus cruentus*	1
Red Brome*	*Bromus rubens*	4
Red Sand-spurrey*	*Spergularia rubra* s.l.	2
Rigid Panic	*Walwhalleya proluta*	1
River Bluebell	*Wahlenbergia fluminalis*	5
River Red-gum	*Eucalyptus camaldulensis*	5
Riverina Bitter-cress	*Cardamine moirensis*	1

Rough Sow-thistle*	*Sonchus asper* s.l.	2
Ruby Saltbush	*Enchylaena tomentosa* var. *tomentosa*	4
Salsify*	*Tragopogon porrifolius* subsp. *porrifolius*	1
Saltbush	*Atriplex* spp.	1
Short-leaf Bluebush	*Maireana brevifolia*	1
Short-wing Saltbush	*Sclerochlamys brachyptera*	2
Sieber Crassula	*Crassula sieberiana* s.l.	1
Silky Goodenia	*Goodenia fascicularis*	2
Skeleton Weed*	*Chondrilla juncea*	1
Slender Hop-bush	*Dodonaea viscosa* subsp. *angustissima*	2
Slender-fruit Saltbush	*Atriplex leptocarpa*	3
Small Knotweed	*Polygonum plebeium*	1
Smooth Cat's-ear*	*Hypochaeris glabra*	7
Smooth Mustard*	*Sisymbrium erysimoides*	2
Southern Cane-grass	*Eragrostis infecunda*	1
Spear Grass	*Austrostipa* spp.	1
Spear Thistle*	*Cirsium vulgare*	2
Spider Grass	*Enteropogon acicularis*	1
Spiny Flat-sedge	*Cyperus gymnocaulos*	1
Spiny Mud-grass	*Pseudoraphis spinescens*	1
Sprawling Bluebell	*Wahlenbergia gracilis*	1
Sprawling Saltbush	*Atriplex suberecta*	1
Spreading Emu-bush	*Eremophila divaricata* subsp. *divaricata*	1
Spreading Sneezeweed	*Centipeda minima* subsp. *minima s.s.*	1
Squat Picris	*Picris squarrosa*	2
Squirrel-tail Fescue*	*Vulpia bromoides*	1
Star Bluebush	*Stelligera endecaspinis*	3
Stiff Cup-flower	*Pogonolepis muelleriana*	1
Stinkwort*	*Dittrichia graveolens*	1
Streaked Copperburr	*Sclerolaena tricuspis*	2
Tall Fireweed	*Senecio runcinifolius*	2
Tangled Lignum	*Duma florulenta*	3
Thorny Lawrencia	*Lawrencia squamata*	1
Tripteris*	*Monoculus monstrosus*	1
Variable Daisy	*Brachyscome ciliaris*	2

Variable Sida	*Sida corrugata*	1
Variable Spear-grass	*Austrostipa scabra/nitida/nodosa* spp. agg.	1
Warrego Summer-grass	*Paspalidium jubiflorum*	3
Water Crassula*	*Crassula natans* var. *minus*	1
Wheel Cactus*	*Opuntia robusta*	1
Wimmera Rye-grass*	*Lolium rigidum*	2
Woolly New Holland Daisy	*Vittadinia gracilis*	1
Yam Daisy	*Microseris* spp.	1
Yellow Twin-heads	*Eclipta platyglossa* subsp. *platyglossa*	1

*Introduced species

Source: (Ecological Associates, 2006; DELWP, 2015)