Environmental Water Management Plan

Murrumbidgee Junction

mallee
catchment management authority

Version Number	Description	Issued To	Issue Date
1.	Draft V1	E. Healy	01/11/2015
2.	Draft V1 Review	M. Cooling (technical review)	03/11/2015
3.	Draft V2	E. Healy	09/12/2015
4.	Updated watering history and changed wetland name from Narrung wetlands to Bidgee Lagoons (Narrung Wetlands) as per the strategy.	J. White	02/02/2018
5.	Updated ecological objectives - Water's Edge Consulting	D. Wood (Mallee CMA)	16/12/2020
6.	Reviewed and updated to align with DEECA guidelines – Alluvium Consulting Australia	E. Johnston (Mallee CMA)	17/05/2024

Acknowledgement of Country

Mallee Catchment Management Authority (CMA) acknowledges and respects Traditional Owners, Aboriginal communities and organisations. We recognise the diversity of their cultures and the deep connections they have with Victoria's lands and waters. We value partnerships with them for the health of people and Country.

Mallee CMA Board, management and staff pay their respects to Elders past, present and emerging and recognise the primacy of Traditional Owners' obligations, rights and responsibilities to use and care for their traditional lands and waters.

Abbreviations and acronyms

ACHRIS	Aboriginal Cultural Heritage Register and Information System
AHD	Australian Height Datum
AM	Adaptive Management
AVIRA	Aquatic Value Identification and Risk Assessment
BWS	Basin Wide Environmental Watering Strategy
CAMBA	China-Australia Migratory Bird Agreement
CEWH	Commonwealth Environmental Water Holder
CMA	Catchment Management Authority
Ctf	Commence to flow
DCCEEW	Department of Climate Change, Energy, the Environment and Water (C'wth)
DEECA	Department of Energy, Environment and Climate Action (Victorian)
DELWP	Department of Environment, Land, Water and Planning (now DEECA)
EPBC	Environment Protection and Biodiversity Conservation
EVC	Ecological Vegetation Class
EWMP	Environmental Water Management Plan
EWP	Environmental Watering Plan
EWR	Environmental Water Reserve
FFG	Flora and Fauna Guarantee
IAP2	International Association of Public Participation
IWC	Index of Wetland Condition
JAMBA	Japan-Australia Migratory Bird Agreement
MDBA	Murray-Darling Basin Authority
LTWP	Long Term Watering Plan
RAP	Registered Aboriginal Party
ROKAMBA	Republic of Korea – Australia Migratory Bird Agreement
SMART	Specific, Measurable, Achievable, Relevant, Time-bound
SWP	Seasonal Watering Proposal
VBA	Victorian Biodiversity Atlas
VEWH	Victorian Environmental Water Holder
VWMS	Victorian Waterway Management Strategy
WMU	Waterway Management Unit

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 hydrological interconnectedness and commonality of threats impacting on the waterway values were used to group them into planning units. This EWMP has been developed for Murrumbidgee Junction which is a subunit of the Boundary Bend WMU. The Murrumbidgee Junction EWMP covers the Bidgee Lagoons (Narrung Wetlands) and Wakool Creek. The EWMP will help to guide future environmental watering activities for this area.

Murrumbidgee Junction is situated on the River Murray 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 provide essential habitat for conservation-listed species including the carpet python. Mature river red gum are also an important source of fallen timber habitat for carpet python on the floodplain. One hundred and twenty-one flora species have been recorded at Murrumbidgee Junction, including eight conservation-listed species. Three of the listed flora species are water dependent.

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). Regular watering (through environmental watering or natural inundation) is required to maintain or improve the condition of river red gum communities. Environmental water was also delivered in 2020/2021.

The long-term 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) 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:

MJ1b: By 2030, improve condition and maintain extent from baseline levels of river red gum (*Eucalyptus camaldulensis*) to sustain communities and processes reliant on mature river red gum at Bidgee Lagoons (Narrung Wetlands), Murrumbidgee Junction

MJ3: By 2030, improve condition and maintain extent from baseline levels of Lignum (*Duma florulenta*) to sustain communities and processes reliant on Lignum communities at Wakool Creek, Murrumbidgee Junction.

MJ4: By 2030, protect and restore biodiversity by maintaining representative populations of small-bodied native fish at Bidgee Lagoons (Narrung Wetlands) Murrumbidgee Junction, including carp gudgeon (*Hypseleotris spp*.), flathead gudgeon (*Philypnodon grandiceps*) and Australian smelt (*Retropinna semoni*).

MJ5: By 2030, improve vital habitat at Bidgee Lagoons (Narrung Wetlands), Murrumbidgee Junction by increasing the diversity of aquatic macrophytes present across a range of Water Regime Indicators Groups.

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 every three years to promote large lignum shrubs with vigorous canopy. Allow water levels to draw down naturally.

The most efficient and effective mechanisms for delivering the optimal water regimes for Bidgee Lagoons (Narrung Wetlands) and Wakool Creek require further investigation. Cultural heritage planning has been undertaken at Bidgee Lagoons (Narrung Wetlands).

Table of Contents

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 Murrumbidgee Junction EWMP was first developed in 2013, and updated in 2015, 2018 and 2020. This version of the document is a full revision of the EWMP, to update content and to align the EWMP with version 6 EWMP Guidelines for rivers and wetlands released by the Department of Energy, Environment and Climate Action (DEECA, formerly DELWP) in 2022 (DELWP 2022).

1.1 PURPOSE AND SCOPE OF AN EWMP

An EWMP is a management plan for a wetland, wetland complex or river system that sets out the environmental watering goals and objectives, and the water regime required to meet the set objectives. An EWMP describes the:

- consultation undertaken for EWMP preparation and implementation
- asset overview and characteristics
- water-dependent environmental values present
- water-related threats to the environmental values
- management goals for the asset
- environmental objectives, targets and values that environmental watering of the asset will support or improve
- watering requirements needed to meet environmental objectives
- environmental water delivery infrastructure, management and constraints
- risks associated with environmental water delivery
- outcomes intended to be demonstrated through monitoring and assessment, and
- knowledge gaps to address

Further information on the purposes of EWMPs and how they relate to other plans, strategies and policies is provided in Appendix 1.

1.2 POLICY CONTEXT

Management of environmental water in Victoria is a statewide partnership between the Victorian Environmental Water Holder (VEWH), catchment management authorities, DEECA, land managers including Parks Victoria and local councils, water corporations, Traditional Owner groups, and interstate agencies including the Commonwealth Environmental Water Holder (CEWH) and the Murray–Darling Basin Authority (MDBA).

Environmental watering in Victoria has historically been supported by management plans such as EWMPs, that document key information including the watering requirements of an asset, predicted ecological responses and water delivery arrangements. These plans support annual decisions about which sites should receive water and help managers evaluate how well assets responded to the water they received or what could be done better.

A range of international treaties, conventions and initiatives, as well as National and State Acts, policies and strategies determine management of the target area. Those with particular relevance to Murrumbidgee Junction and the management of its environmental values are listed in Table 1.

Table 1. Legislation, conventions, and listings relevant to the target area

Legislation, Agreement or Convention	Jurisdiction
Environment Protection and Biodiversity Conservation Act 1999 (EPBC)	National
Flora and Fauna Guarantee Act 1988 (FFG)	State
China - Australia Migratory Bird Agreement (CAMBA) *Japan - Australia Migratory Bird Agreement (JAMBA)* *Republic of Korea - Australia Migratory Bird Agreement (ROKAMBA)*	*National (relevant international agreements are administered under the EPBC Act)*

A regional context document (North, 2014) has been prepared to compliment the Mallee CMA EWMPs and should be read in conjunction with this document. The functions and major elements of each policy instrument in Table 1 are described in the regional content document.

A number of earlier investigations into the River Murray 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, several 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 River Murray – Nyah to Robinvale (Ecological Associates, 2006).

DEECA, Parks Victoria and the Mallee CMA have invested significant resources into the area in recent years in both environmental watering in 2005 and 2020/2021 and complementary on ground works such as track upgrading, pest plant and animal control, and improved signage to decrease recreational pressures on the floodplain.

2 Partnership and Consultation

2.1 TARGET AUDIENCE

This section identifies the target audience and modes of consultation necessary to manage environmental water delivery, report against stated objectives and targets, and promote adaptive management over the life of the EWMP.

Engagement with different stakeholder groups is based on the International Association of Public Participation (IAP2) spectrum (Figure 1). The spectrum allows for a tailored approach based on stakeholder groups and their needs.

IAP2 Spectrum of Public Participation

IAP2's Spectrum of Public Participation was designed to assist with the selection of the level of participation that defines the public's role in any public participation process. The Spectrum is used internationally, and it is found in public participation plans around the world.

INCREASING IMPACT ON THE DECISION

	INFORM	CONSULT	INVOLVE	COLLABORATE	EMPOWER
PUBLIC PARTICIPATION GOAL	To provide the public with balanced and objective information to assist them in understanding the problem, alternatives, opportunities and/or solutions.	To obtain public feedback on analysis, alternatives and/or decisions.	To work directly with the public throughout the process to ensure that public concerns and aspirations are consistently understood and considered.	To partner with the public in each aspect of the decision including the development of alternatives and the identification of the preferred solution.	To place final decision making in the hands of the public.
PROMISE TO THE PUBLIC	We will keep you informed.	We will keep you informed, listen to and acknowledge concerns and aspirations, and provide feedback on how public input influenced the decision.	We will work with you to ensure that your concerns and aspirations are directly reflected in the alternatives developed and provide feedback on how public input influenced the decision.	We will look to you for advice and innovation in formulating solutions and incorporate your advice and recommendations into the decisions to the maximum extent possible.	We will implement what you decide.

Figure 1. IAP2 Spectrum (Source: (c) International Association for Public Participation www.iap2.org)

Table 2 lists the main stakeholder groups with an interest in environmental water based on their needs and interests and level of engagement required. To read more about the role of specific stakeholders in environmental water at Murrumbidgee Junction, refer to Sections 3.2 and 3.4.

Mallee CMA develops a communication and engagement plan each year that covers environmental watering events for the entire Mallee CMA region, including Murrumbidgee Junction. This ensures that all stakeholders and community members are aware of the Murrumbidgee Junction environmental watering operations.

Table 2. Stakeholder groups with an interest in environmental water at Murrumbidgee Junction

Stakeholder groups	Stakeholders	Needs and interests	IAP2 level	Consultation modes
Public land managers	Parks Victoria	Managing impacts from watering such as access, State-level environmental management	Collaborate	Monthly Meetings
	Department of Energy, Environment and Climate Action	State level environmental management planning, land manager, threatened species manager	Collaborate	Monthly Meetings
	Mallee CMA	Regional waterway and environmental management	N/A	N/A
Local government	Swan Hill Rural City Council	Access during watering events	Involve	Meetings, phone calls, correspondence
Aboriginal Stakeholders	See also Section 2.4: Traditional Owners	Ongoing connection to Country and protection of cultural heritage and values. Environmental impacts and benefits. Environmental watering regimes and how these may be timed to support/promote cultural values. Assistance in planning and implementation of programs.	Involve	Ongoing engagement with Mallee CMA's Aboriginal engagement team. Engagement is largely undertaken in-person and, where possible, on Country
Environmental Water Holders	Victorian Environmental Water Holder	Decision-making around annual environmental water usage	Collaborate	Formal Meetings
Private landholders	Local landholders	Assistance in planning and implementation of programs	Inform	
Community representatives	• Boundary Bend community • Mildura BirdLife • Kooloonong Natya Landcare Group	Watering benefits and impacts on local communities, such as access to parks and river during watering events	Consult	Existing groups such as the Mallee CMA Land and Water Committee Mallee CMA social media and news.

2.2 DEVELOPING/UPDATING THE EWMP

In the development of this EWMP, Mallee CMA carried out community consultation in the following ways:

- Discussions with the Mallee CMA Land and Water Advisory Committee
- Workshops and on-Country engagement with Traditional Owners (see Section 2.4)
- Meetings with agency stakeholders
- Meetings with landholders
- Online surveys
- In-person engagement at local events such as markets and environmental group meetings
- Social media platforms.

2.2.1 Verifying asset values

Asset values at Murrumbidgee Junction have been established through environmental assessments and the development of previous versions of this EWMP. Consultation has been a key part of these processes with Traditional Owners, community members and technical specialists. Mallee CMA has continued to engage on asset values throughout the development of the EWMP, particularly with Traditional Owners and private and public landholders.

2.2.2 Informing proposed management objectives, targets and approaches

Mallee CMA has a long working relationship with those who have an extensive knowledge of Murrumbidgee Junction and floodplain ecosystems. This work has been central to providing a basis for local knowledge and expertise.

Combined with the Seasonal Watering Proposal, the data and knowledge from the proposed monitoring activities will guide future watering events, as part of the adaptive management approach.

2.2.3 Promoting adaptive management

Mallee CMA and other partners will take an adaptive management approach taking into account both varying seasonal conditions and lessons learned from previous events.

After the annual adaptive management checkpoint, Mallee CMA will adapt the EWMP if needed, which would then go through consultation, giving stakeholders the opportunity to see any updates.

2.3 COMMUNITY ENGAGEMENT

Community stakeholders were engaged in-person during local events such as local markets and local environmental group meetings. This engagement included a 'Pins in Maps' activity, where the community provided information on uses and values at specific locations at the site.

Community stakeholders were also engaged via an online survey, which was hosted on the Mallee CMA website in December 2023 – January 2024. The survey was designed to enable community, landholders, recreational users, environmental groups and other interested parties to provide input to the plans. The survey supplements earlier community engagement about the Murrumbidgee Junction EWMP, and annual community engagement that informs the Seasonal Watering Proposal (SWP). Community consultation occurs at the IAP2 level of CONSULT. Community engagement responses are summarised in Appendix 2.

2.4 TRADITIONAL OWNERS

Engagement with Traditional Owners was conducted in an intimate group setting at the INVOLVE level of the IAP2 framework, with the level of interest and involvement self-determined by the group. Mallee CMA held discussions with Traditional Owners Culpra Milli Aboriginal Corporation, Gilbie Aboriginal Corporation, Munatunga Elders, Tati Tati Land and Water Indigenous Corporation, Wadi Wadi Nation, Tati Tati Wadi Wadi Land and Water Indigenous Corporation, and Dadi Dadi Weki Weki Aboriginal Corporation on Country at Wakool Creek in November 2023. Through this engagement activity, Traditional Owner stakeholders were asked to identify the cultural values/uses at specific sites by placing pins on a map where these cultural values occurred. Information from this consultation has informed cultural site use and cultural values incorporated into this EWMP.

This follows consultation with Traditional Owners on previous iterations of the EWMP. In-line with EWMP guidelines, consultation with Traditional Owners is ongoing.

3 Asset Overview

The Mallee CMA region is situated in the north-west of Victoria. The area of responsibility is close to 39,000 km2 (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 River Murray corridor which contributes over 40% of the value of agricultural production for the region.

The site for this plan is the Murrumbidgee Junction which is a subunit of the Boundary Bend WMU and located 45km south east of Robinvale on the River Murray floodplain (Figure 2).

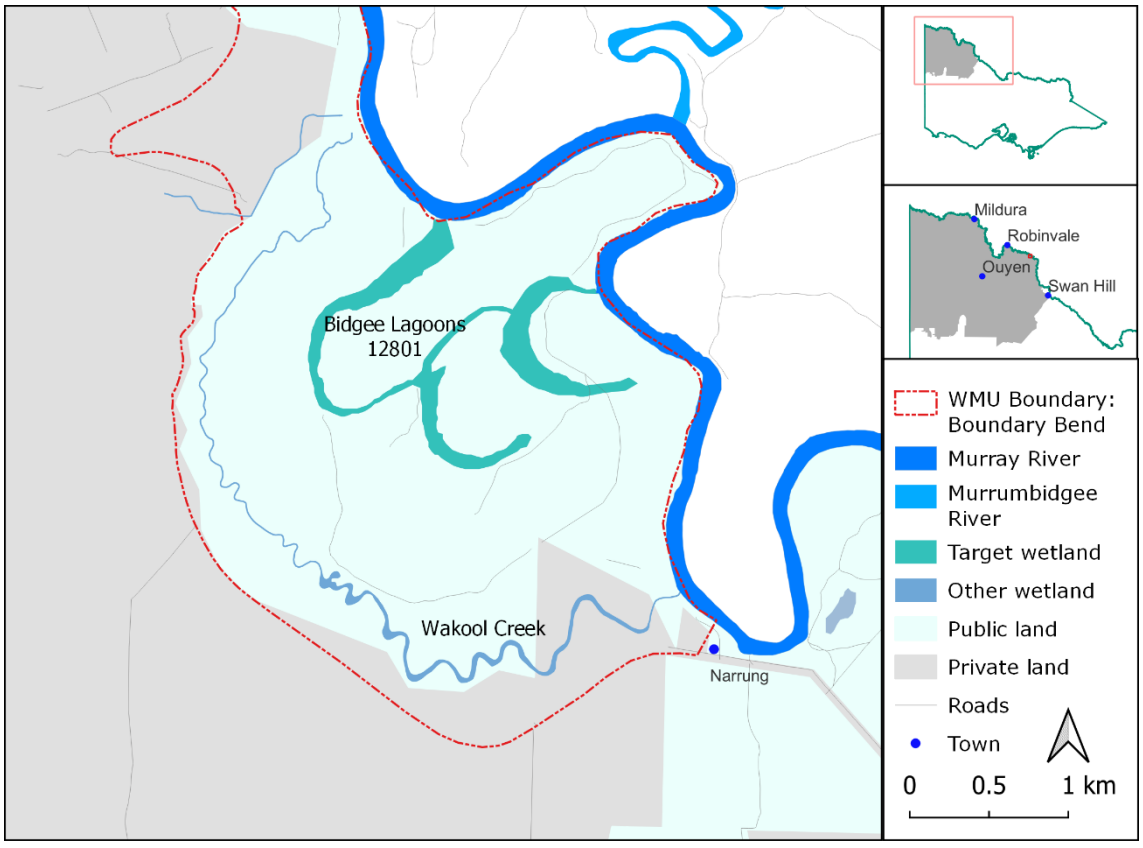


Figure 2. Murrumbidgee Junction

3.1 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).

Murrumbidgee Junction is situated on the River Murray floodplain, south east of Robinvale near Narrung. The site is immediately north west of the Heywood Lake subunit of the Heywood WMU and Heywood Lake Wildlife Reserve, and north east of the Yungera Bushland Reserve. Murrumbidgee Junction is part of the extensive floodplain complexes that extends along the River Murray and the Murrumbidgee River.

There are four distinct wetlands present; three connected deep freshwater billabongs that are together known as Bidgee Lagoons (Narrung Wetlands) (wetland #12801) 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 land uses include dryland cropping and irrigated horticulture.

3.2 LAND STATUS AND MANAGAGEMENT

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.

Several agencies and individuals are involved in managing the land and water at Murrumbidgee Junction (Table 3). Land management boundaries are shown in Figure 2.

Table 3. Land and water Managers at Murrumbidgee Junction

Organisation	**Management Role**
Minister for Water (Vic), DEECA	• Oversee Victoria's environmental water management policy framework, and its implementation. • Administer the broader water allocation and entitlements framework and the Water Act 1989 (Vic).
Mallee CMA	• The waterway manager that plans and identifies environmental water needs across the Mallee region Water Act 1989 (Vic). • Approves and manages delivery of environmental water and monitoring and reporting of outcomes, in accordance with ecological objectives.
Parks Victoria	• The land manager for the Crown land under the *National Parks Act 1975* (Vic) and *Crown Land (Reserves) Act 1978* (Vic) • Manages pests and specific environmental impacts. • Supports watering on public land and manages any impacts, for example by engaging with site visitors about environmental water-related matters and managing public access during and after an event.
Victorian Environmental Water Holder	• Manager of Victoria's environmental water entitlements
Private Landholders	• Land managers of western and southern fringes of the Murrumbidgee Junction WMU sub-unit

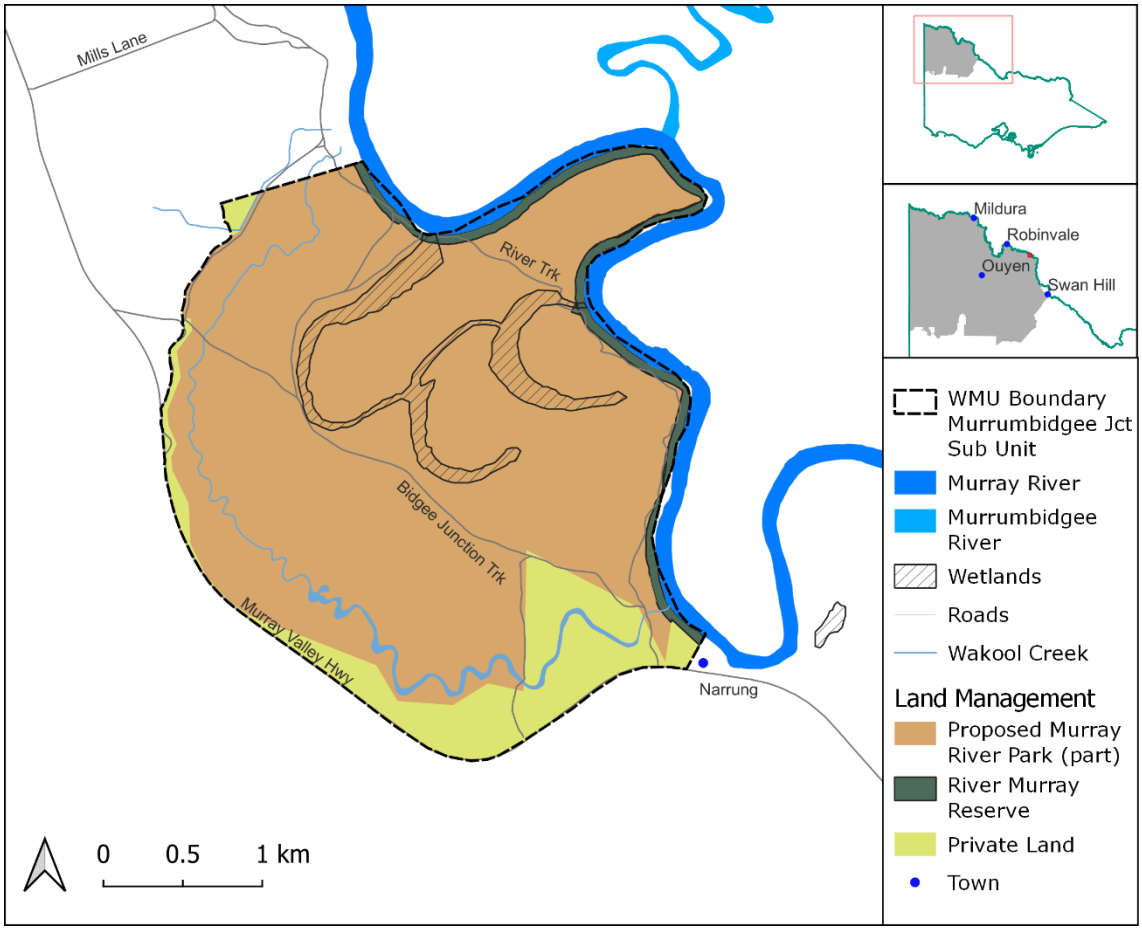


Figure 3. Land management boundaries at Murrumbidgee Junction

3.3 ASSET CHARACTERISTICS

An overview of the main characteristics of the wetlands at Murrumbidgee Junction is provided in Table 4. Wetland types found within Murrumbidgee Junction are shown in Figure 4.

Table 4. Wetland characteristics

Characteristics	Description
Name	Murrumbidgee Junction
Mapping ID (Wetland Current layer)	Bidgee Lagoons (Narrung Wetlands): 12801 Wakool Creek: not listed
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 Reserve, Murray River Park (proposed), private land
Land manager	Parks Victoria, DEECA, Private

Characteristics	Description
Surrounding land use	Farming zone: broad acre dryland cropping and irrigated horticulture; townships of Boundary Bend and Narrung
Water supply	Natural inflows from the River Murray and local catchment runoff
Wetland category (Current wetland layer)	Bidgee Lagoons (Narrung Wetlands) (12801): Unknown. Deep freshwater marsh Corrick class. Wakool Creek (no ID): Not classified. Freshwater meadow Corrick class
Wetland depth at capacity	Approximately 4 m at deepest point

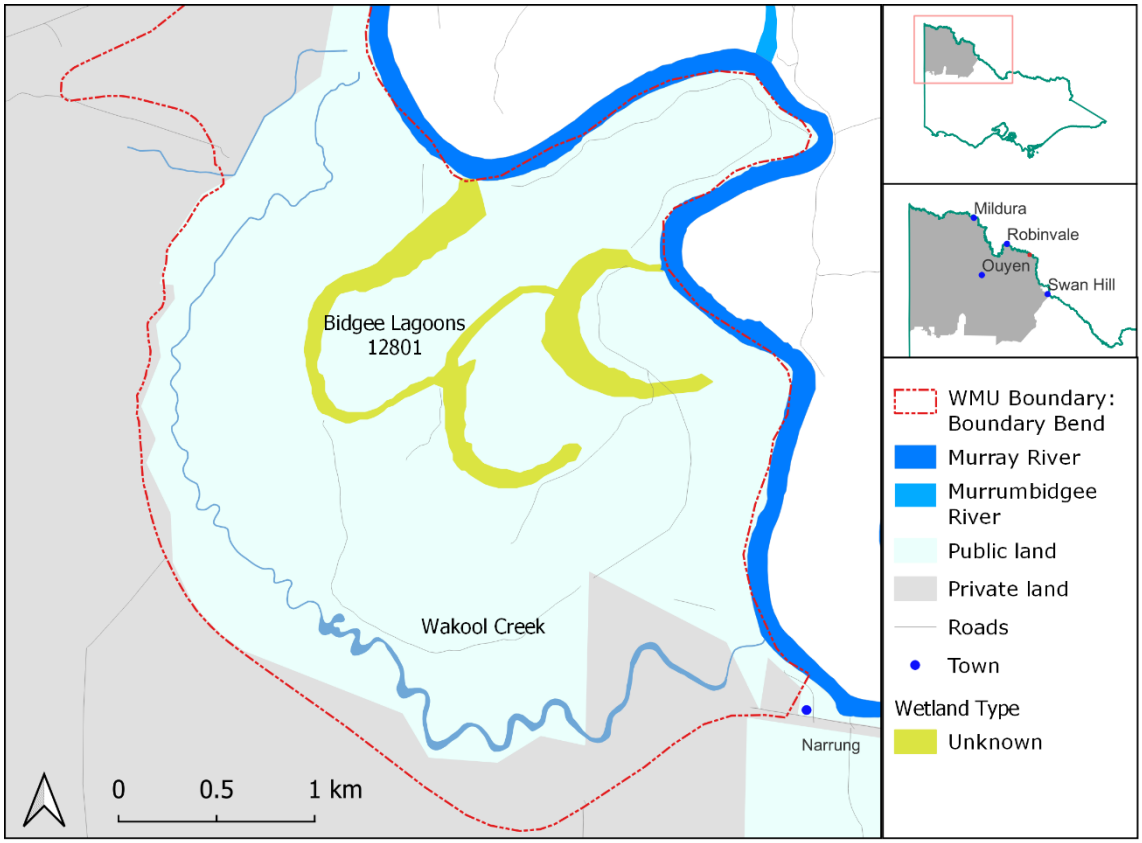


Figure 4. Wetland Types (according to the wetland current spatial layer) at Murrumbidgee Junction

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 5.

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

Expansion of the target area is possible only with significant alterations to River Murray 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.

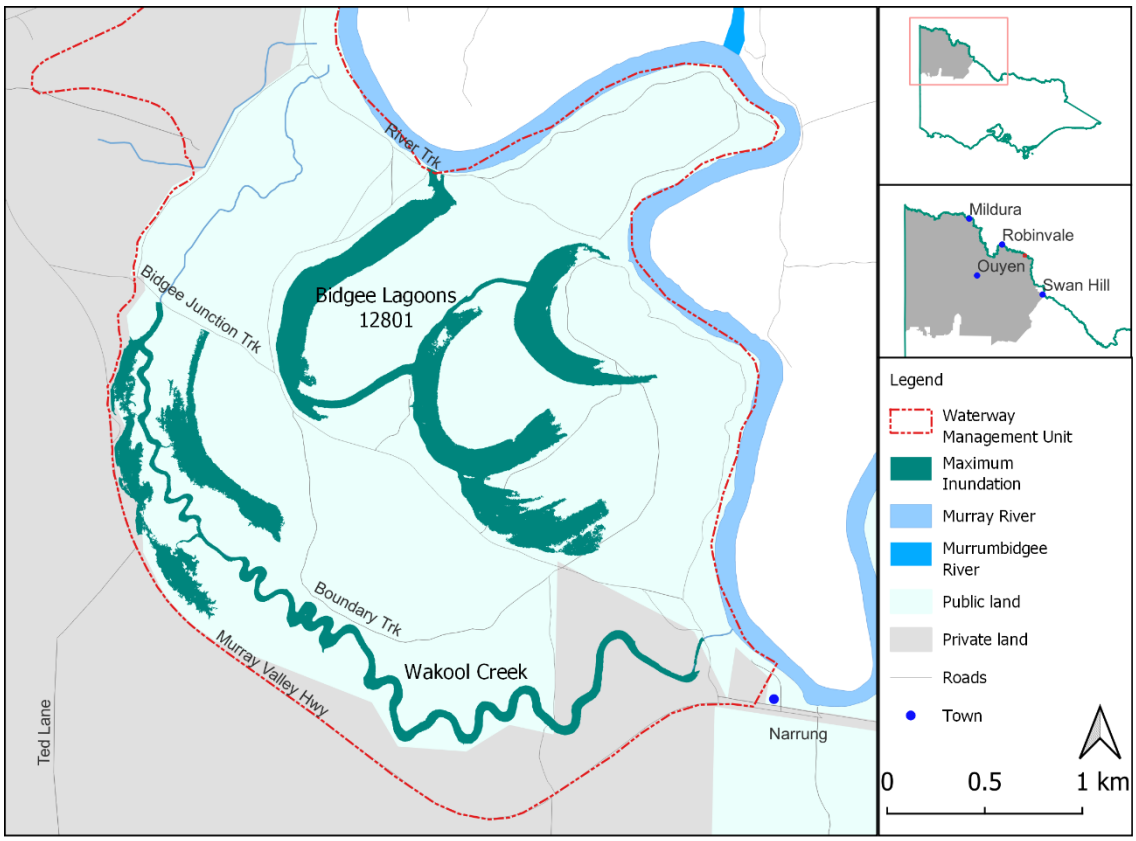


Figure 5. Target area and maximum inundation extent at Murrumbidgee Junction

3.3.1 Conceptualisation of the site

Murrumbidgee Junction is represented in a conceptual model in Figure 6. This is a visual representation of the processes and components within the target area that are discussed throughout this EWMP.

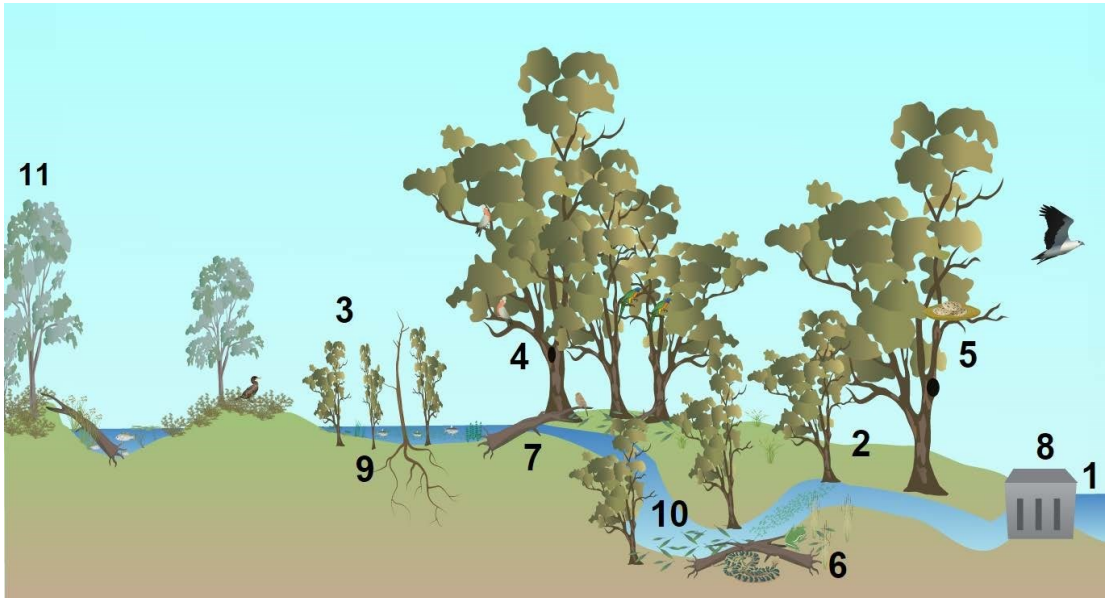


Figure 6. Conceptualisation of Murrumbidgee Junction. Graphic developed using software provided by the Integration and Application Network, University of Maryland Centre for Environmental Science (ian.umces.edu/symbols/).

Wakool Creek diverges from the River Murray 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 River Murray 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 River Murray. 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.

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.

Significant mature, hollow bearing river red gum are plentiful at the site, lining the connecting channels and wetlands.

Hollows in mature river red gum provide important habitat for fauna including carpet pythons.

Fallen woody debris provides feeding sites for ground foraging birds; thick leaf litter and fallen logs with hollows provide shelter for the carpet python and other snakes and lizards.

3) 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.

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.

4) The movement of water between Wakool Creek, smaller floodplain channels, Bidgee Lagoons (Narrung Wetlands) and the River Murray will entrain nutrients and carbon, release and transport seeds, and increase macrophyte diversity.
5) Lignum Shrubland within Wakool Creek may provide habitat for waterbird roosting and nesting.

3.4 ENVIRONMENTAL WATER SOURCES

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

The VEWH is responsible for holding and managing Victoria's environmental water entitlements and sourcing water from the Victorian Murray system for delivery to Bidgee Lagoons and Wakool Creek. This could include water held by the VEWH or CEWH. Details of the VEWH's environmental water entitlements are available at: https://www.vewh.vic.gov.au/watering-program/how-much-water-is-available.

4 Current/Historical Hydrological Regime 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 River Murray 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).

Floodplain at Murrumbidgee Junction

Unlike many other wetlands on the Murray floodplain, there are no significant local structures, such as dams and levees, impacting the hydrology of the Murrumbidgee Junction floodplain and wetlands. The regulation and diversion of the River Murray has reduced the frequency and duration of peaks in river flow which activate anabranches, fill wetlands and inundate floodplain areas. The floodplain flats around Wakool Creek and Murrumbidgee Junction are engaged when River Murray flows exceed approximately 30,000 ML/day upstream of the Murrumbidgee River confluence, and 50,000 ML/day downstream of the Murrumbidgee confluence (Ecological Associates, 2006).

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

Therefore, prior to river regulation in this reach of the River Murray. Under pre-regulation 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.

Bidgee Lagoons (Narrung Wetlands)

The three large deep billabongs that form Bidgee Lagoons (Narrung Wetlands) are linked by a distinct creek line. As River Murray levels rise, water initially fills the most downstream of the three wetlands via a low effluent, which is connected to the River Murray 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).

Local knowledge has identified that the inundation threshold for Bidgee Lagoons (Narrung Wetlands) is 25,000 ML/day (Table 5). 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 post-regulation. The median duration of inundation events has also been reduced from 183 days to 100 days since river regulation.

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). 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.

Wakool Creek

Wakool Creek follows the landward perimeter of the floodplain. There is little information on the flow behaviour of the creek and the inundation threshold for Wakool Creek is unknown, although modelling by Ecological Associates (2006) estimate it to be between 30,000 ML/day and 60,000 ML/day (Table 5).

Ecological Associates (2006) suggest that the creek fills initially from downstream and as river 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.

A 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 60,000 ML/day.

Table 5. Commence to flow rate (River Murray Gauge 414203) for Murrumbidgee Junction target areas

Waterbody	Commence to flow rate (in River Murray at gauge #414203)
Bidgee Lagoons	25,000 ML/d
Wakool Creek	Estimated 30,000 ML/d to 60,000 ML/d

4.1 GROUNDWATER AND SALINITY INTERACTIONS

Groundwater and salinity interactions at Murrumbidgee Junction are a knowledge gap.

4.2 ENVIRONMENTAL WATERING

Environmental watering was provided to the Bidgee Lagoons (Narrung Wetlands) in 2005 and 2006; details are presented in Table 6. 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. Such losses should be considered for future watering events at Murrumbidgee Junction.

Table 6. A Summary of environmental watering at Murrumbidgee Junction

Water year	Waterbody	Time of inflow	Environmental Water Source	Total volume delivered (ML)	Area (ha) inundated
2005	Bidgee Lagoons	Spring	Surplus flows	1019	100
	Bidgee Lagoons		Bulk entitlement		
2006	Bidgee Lagoons	Autumn	Bulk entitlement	640	100
2010/2011	Bidgee Lagoons and Wakool Creek	Spring, Summer and Autumn	Natural flows	n/a	Full
2011	Bidgee Lagoons	Spring	Natural flows	n/a	Partial
2012	Bidgee Lagoons	Spring	Natural flows	n/a	Full
2012	Wakool Creek	Spring	Natural flows	n/a	Partial
2016	Bidgee Lagoons and Wakool Creek	Spring and Summer	Natural flows	n/a	Full
2020/2021	Bidgee Lagoons	Spring	VEWH	450	Partial
2021/2022	Bidgee Lagoons	Spring	Natural flows	n/a	Partial
2022/2023	Bidgee Lagoons and Wakool Creek	Spring and Summer	Natural flows	n/a	Full
2023/2024	Bidgee Lagoons and Wakool Creek	Spring and Summer	Natural flows	n/a	Partial

The 2005/2006 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 River Murray 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. Environmental water was again delivered in 2020/2021, and the area has been naturally inundated on several occasions.

5 Water Dependent Values

5.1 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.

5.1.1 Ecosystem type and function

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 diversity of feeding, breeding and nursery sites for native water-dependent biota.

The mature river red gum at this site provide essential habitat for the conservation-listed carpet python. 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).

5.1.2 Flora and Fauna Values

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) (accessed via NatureKit, 2023) 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.

Ecological Vegetation Classes (EVCs)

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 7 displays the spatial arrangement of the EVCs, and Appendix 3 provides detailed descriptions of the EVCs.

Table 7. Ecological Vegetation Classes modelled as present within the Murrumbidgee Junction target area.

EVC Number	EVC Name	Area modelled as present within target area (ha)	Bioregional Conservation Status Murray Fans	Murray Mallee
810	Floodway Pond Herbland	30.049	Depleted	n/a (vulnerable)
200	Shallow Freshwater Marsh	22.080	Vulnerable	n/a (vulnerable)
808	Lignum Shrubland	21.900	Vulnerable	Least Concern
809	Floodplain Grassy Wetland	16.498	Endangered	n/a (endangered)
818	Shrubby Riverine Woodland	12.628	Least Concern	n/a (Least concern)
-	Bare Rock/Ground	9.777	-	-
823	Lignum Swampy Woodland	4.549	Vulnerable	n/a (vulnerable)
103	Riverine Chenopod Woodland	3.926	Endangered	n/a (depleted)
811	Grassy Riverine Forest / Floodway Pond Herbland Complex	2.492	n/a	n/a
106	Grassy Riverine Forest	0.152	Depleted	n/a (depleted)
824	Woorinen Mallee	0.089	Vulnerable	Vulnerable
97	Semi-arid Woodland	0.011	Vulnerable	n/a (vulnerable)
86	Woorinen Sands Mallee	0.004	Depleted	Depleted

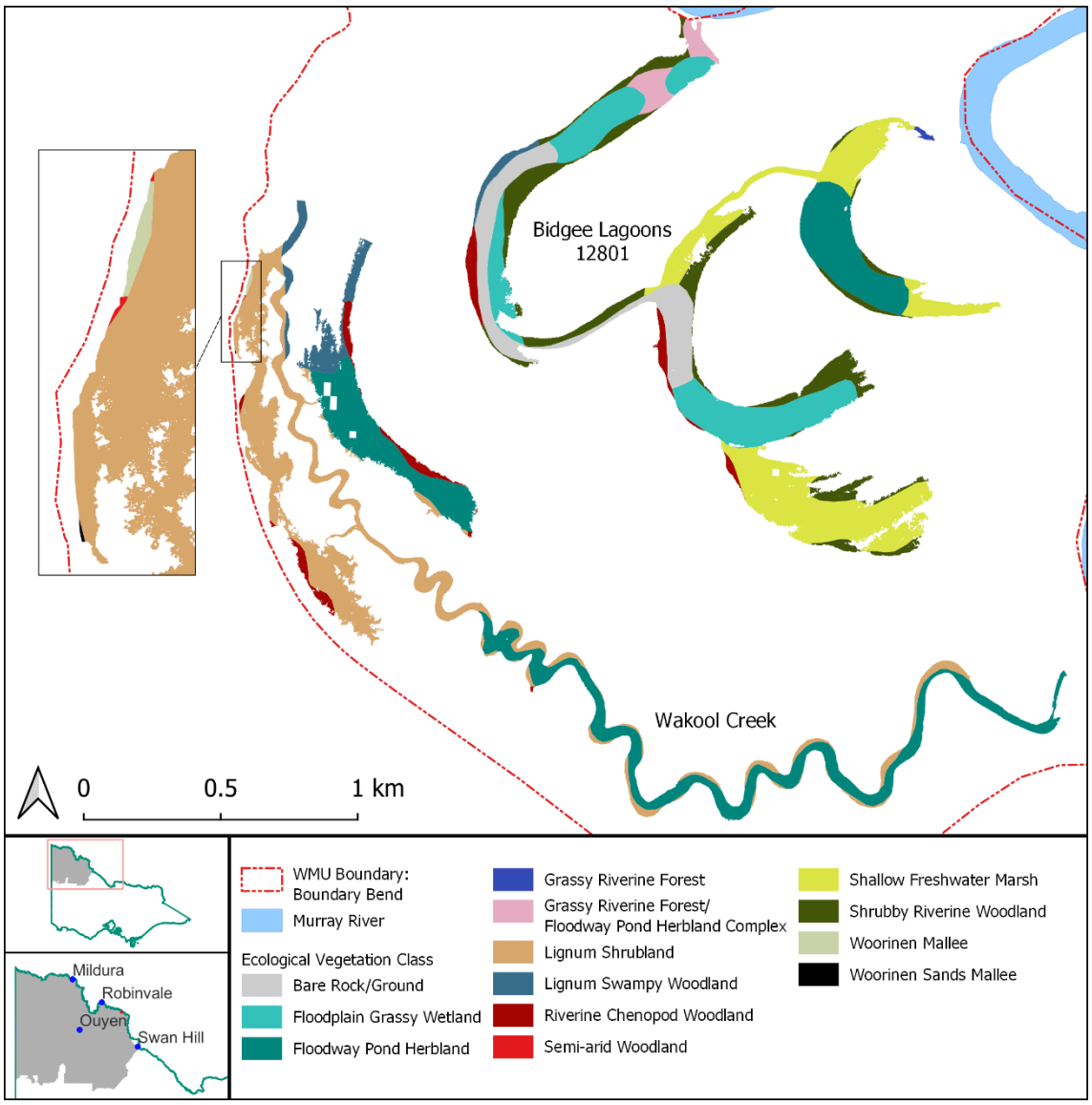


Figure 7. Ecological vegetation classes within the maximum inundation target area at Murrumbidgee Junction

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 8).

Figure 8. Drainage lines will support a mix of aquatic and ephemeral herbs and grasses during and after inundation (dry phase shown, Sept 2015)

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 9).

Figure 9. Grassy Riverine Forest is present along the floodplains and channel connecting Bidgee Lagoons (Narrung Wetlands) to the River Murray (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 10).

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 nearby this site.

Figure 10. 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).

Wetland depletion and rarity

The conservation significance of Victorian wetland types has been determined by comparing the estimated extent prior to European settlement with the remaining extent in 1994.

Murrumbidgee Junction contains two wetland types under the Corrick classification: Deep Freshwater Marsh (the wetlands that comprise Bidgee Lagoons) and Freshwater Meadow (Wakool Creek).

A large proportion of these wetland types have been lost in Victoria. Forty-five per cent of Freshwater Meadow area 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 8) (DNRE, 1997).

Table 8. Regional change in area of Corrick wetland type

Corrick category	Wetland name	Total area (ha)	Percentage change in wetland area from 1788 to 1994		
			Change in Victoria	Change in Mallee CMA	Change in Murray Fans bioregion
Deep freshwater marsh	Bidgee Lagoons	30.4 ha	-70%	-45%	-6%
Freshwater Meadow	Wakool Creek	28.05 ha	-45%	-80%	-63%

Fauna

Twenty species of fauna have been observed within the Murrumbidgee Junction WMU subunit area (Appendix 4). Two of these species, Murray cod (*Maccullochella peelii*) and the carpet python (*Morelia spilota metcalfei*), are conservation-listed under Victorian and Commonwealth legislation (Table 9)

Table 9. Listed species of fauna observed at Murrumbidgee Junction

Scientific name	Common name	FFG Act status	EPBC Act status
Morelia spilota metcalfei	Carpet python	Endangered	Not listed
Maccullochella peelii	Murray cod	Vulnerable	Endangered

The deep open water habitat of Bidgee Lagoon can support opportunistic breeding by large bodied native fish, and Murray cod (*Maccullochella peelii*) have been recorded at the site. Murray cod are considered main channel specialists as this is where they spawn and recruit, though juveniles may possibly be found in the floodplain and lakes (Rogers and Ralph, 2011).

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).

The brown treecreeper (*Climacteris picumnus)*, regent parrot (*Polytelis anthopeplus monarchoides),* Major Mitchell's cockatoo (*Lophocroa leadbeateri*) and White-bellied sea eagle (*Haliaeetus leucogaster)* have been observed nearby but observation sites were outside the search boundary used to generate flora and fauna lists. These species are predicted to utilise the Murrumbidgee Junction target area and are regarded as indirectly water dependent due to their habitat requirements (e.g. dependent on nesting hollows in riparian trees).

Flora

121 species of flora have been recorded at Murrumbidgee junction (Appendix 5), including eight conservation-listed species under the FFG Act (Table 10).

Table 10. Listed flora recorded at Murrumbidgee Junction

Scientific Name	Common Name	FFG Act Status	EPBC Act Status
Cullen discolor	Grey scurf-pea	Endangered	n/a
Swainsona phacoides	Dwarf swainson-pea	Endangered	n/a
Cardamine moirensis	Riverina bitter-cress	Endangered	n/a
Calostemma luteum	Yellow garland-lily	Endangered	n/a
Picris squarrosa	Squat picris	Endangered	n/a
Centipeda nidiformis	Cotton sneezeweed	Endangered	n/a
Leichhardtia australis	Doubah	Endangered	n/a
Eremophila divaricata subsp. divaricata	Spreading emu-bush	Vulnerable	n/a

Of the listed species, riverina bitter-cress (*Cardamine moirensis)*, cotton sneezeweed (*Centipeda nidiformis)*, and squat picris (*Picris squarrosa)* are water-dependent species as they are found around lakes, watercourses and/or on floodplains.

5.1.3 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, watering history 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, 2015). 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. Wakool Creek has been inundated four times in recent years via natural flows (2010/11, 2016, 2022/23 and 2023/24, refer to Table 6), although has not received water from an environmental water entitlement. As the site has only received water in 3 of every 10 years, the water regime target for Wakool Creek (watering in 5 of every 10 years) is not being met.

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. The Bidgee Lagoons (Narrung Wetlands) have been watered on five occasions since 2016, mostly through natural flows, and once using the Bulk Entitlement (2010/2011, Table 6). The water regime target of watering in 3 or every 10 years, is currently being met.

5.2 SHARED BENEFITS

5.2.1 Traditional Owner Cultural Values

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 the natural landscapes of the Mallee.

In Indigenous culture, water is inseparable from the land, air, plants and animals. Caring for, and healing, Country is an inherited cultural obligation that is reliant upon having water in the landscape in the right place, at the right time of year. Water creates and sustains life, and is a living and cultural entity that connects Traditional Owners to Ancestors, Country, cultural practice and identity. Traditional Owners have an ongoing connection to the wetlands at Murrumbidgee Junction and community members are invested in the ecological health and sustainable management of water at the site.

Within the Mallee CMA region, the River Murray and its associated waterways continue to be culturally significant areas for many Aboriginal groups. The high number of Indigenous cultural heritage sites throughout the Murray floodplain is unique in Victoria because of their concentration and diversity. It is typical to find high densities of identified Indigenous cultural heritage sites located around, or close to, freshwater sources. The Aboriginal Heritage Regulations 2018 define "areas of cultural heritage sensitivity" which include land within 200 m of named waterways and land within 50 m of registered Aboriginal cultural heritage places. A review of the Aboriginal Cultural Heritage Register and Information System (ACHRIS) confirms that Bidgee Lagoons (Narrung Wetlands), Wakool Creek and the River Murray are defined as areas of cultural heritage sensitivity.

Indigenous representation for Murrumbidgee Junction during the most recent update of this EWMP included Culpra Milli Aboriginal Corporation, The Pearce Family, Munatunga Elders, Tati Tati Land and Water, Wadi Wadi Nation, Tati Tati Wadi Wadi Land and Water, and Dadi Dadi Weki Weki community representatives. There is currently no Registered Aboriginal Party (RAP) appointed for Murrumbidgee Junction.

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 (Bell, 2012).

5.2.2 European Heritage Values

European heritage sites reflect the pioneering history of the area. 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).

5.2.3 Recreational Values

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. Nearby Passage Camp provides fireplaces for campers and a walking trail to the old Narrung town site. VEAC (2008) recommended that camping and campfires continue to be permitted in the area.

5.2.4 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 have a population of 154 (Australian Bureau of Statistics 2021).

5.2.5 Educational Values

Murrumbidgee Junction is not known to be currently used for educational purposes.

5.3 TRAJECTORY OF CHANGE

Overall, Murrumbidgee Junction retains some significant environmental, cultural and social values and vegetation health is relatively good. In the absence of watering however, the condition of the Murrumbidgee Junction target area is anticipated to decline.

The site was watered in 2005 as an emergency response to declines in river red gum health. Monitoring after the 2005/2006 watering event suggested that watering led improvements in river red gum condition and regeneration within the wetlands. In the absence of follow-up watering many of these recruited trees died or were in serious decline by the time they were naturally inundated in 2010/2011.

Regular inundation is therefore required to maintain the condition and extent of river red gum and lignum, without which, declines in condition are expected. Frequent inundation is also required to maintain ecosystem resilience across periods of successive dry years and drought, and for ecological communities to be able to subsequently capitalise on average and wet conditions. Improvements to the water regime outlined in this EWMP will help to build this resilience.

6 Managing 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)
- Changed water regime – Bidgee Lagoons (Narrung Wetlands)
- Increase in Low Flow Magnitude – 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 River Murray. 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 (River Murray), 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 are likely to 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 and frog 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. Fallen large wood in terrestrial areas provides important habitat for carpet pythons. 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.

Managing water-related threats

Management of water related threats at Murrumbidgee Junction is undertaken through maintaining the optimal watering regime. As part of this process, the wetlands will periodically be allowed to dry out, enabling the reduction of invasive aquatic species such as European carp. Drawdown and inundation of wetlands in line with the optimal watering regime will also manage invasive flora species not suited to natural water cycles.

ASSESSING RISK

Consideration of risk provides a link between recognition of system threats and key management processes, including decade and seasonal planning. Risk assessments are composed of both likelihood and consequence components. In this instance, likelihood is influenced by the probability that there will be sufficient environmental water to maintain creek flows and water levels.

From a seasonal watering perspective, prioritisation of watering actions will be based on consequence. While consequence for an individual wetland can be determined, environmental water allocations require consideration of the consequences at larger scales. For the Mallee CMA it is their region, for the VEWH it is Victoria and the CEWH it is the Murray Darling Basin.

Not all consequences can be identified as readily and so a process for assessing risk is provided in Appendix 6.

7 Management Goals, Objectives and Targets

7.1 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.

This goal is linked to the goals of the Mallee Waterway Strategy 2014-2022 (Mallee CMA 2014), which are to:

- maintain or improve habitat within waterways and on surrounding riparian land;
- manage all land tenures for water quality benefits and respond appropriately to threatening events (both natural and pollution based);
- restore appropriate water regimes and improve connectivity;
- protect the extent and condition of Cultural Heritage (Indigenous and non-Indigenous) sites associated with waterways; and
- increase community capacity for, awareness of and participation in waterway management.

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

- Stock Bidgee Lagoons (Narrung Wetlands) 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 (Management activity number F1.2).
- Maintain depth gauges at Murrumbidgee Junction (Management activity number F1.5).

These activities and goals have been considered in the development of this EWMP.

7.2 ENVIRONMENTAL OBJECTIVES AND TARGETS

Environmental objectives represent the desired environmental outcomes of the site based on the management goal, above, as well as the key values outlined in the Water Dependent Values section. It is intended that EWMP objectives will be described in terms of the primary environmental outcomes, in most cases ecological attributes. The focus of the objectives should be on the final ecological outcomes and not the drivers per se.

During 2020, the environmental objectives (formally ecological objectives) were analysed and refined with the intent of improving the specificity and measurability of the objectives through the development of targets, and to improve line of sight to the Basin Plan. While the process attempted to maintain the intent and integrity

of the original objectives, it provided an opportunity to reassess the suitability of these objectives for the asset. The rationalisation, assessment of SMARTness, mapping to Basin Plan and update of each objective for Murrumbidgee Junction can be found in Section 5.18.1 of Butcher et al. (2020) and are provided in Appendix 7.

While every attempt has been made to make the following objectives and targets as complete as possible, gaps remain as critical information is not currently available. As such, baselines are not able to be set at this time. In the interests of moving forward, the objectives and targets have been written in a way (i.e. red highlighted text) that allows this information to be included at a later stage as this information becomes available.

Table 11. Updated environmental objectives for Murrumbidgee Junction

EWMP Objective	Target
MJ1b: By 2030, improve condition and maintain extent from baseline levels of river red gum (*Eucalyptus camaldulensis*) to sustain communities and processes reliant on mature river red gum at Bidgee Lagoons (Narrung Wetlands), Murrumbidgee Junction	By 2030, a positive trend in the condition score of river red gum dominated EVC benchmarks at 80% of sites over the 10 year period OR By 2030, at stressed sites (see Wallace et al. 2020): in standardised transects that span the floodplain elevation gradient and existing spatial distribution, ≥70% of viable trees will have a Tree Condition Index Score (TCI) ≥ 10. Baseline condition of trees at Bidgee Lagoons (Narrung Wetlands), Murrumbidgee Junction to be established.
MJ3: By 2030, improve condition and maintain extent from baseline levels of lignum (*Duma florulenta*) to sustain communities and processes reliant on lignum communities at Wakool Creek, Murrumbidgee Junction.	By 2030, condition in standardised transects that span the floodplain elevation gradient and existing spatial distribution, ≥70% of lignum plants in good condition with a lignum Condition Score (LCI) ≥4.
MJ4: By 2030, protect and restore biodiversity by maintaining representative populations of small-bodied native fish at Bidgee Lagoons (Narrung Wetlands) Murrumbidgee Junction, including carp gudgeon (*Hypseleotris* spp.), flathead gudgeon (*Philypnodon grandiceps*) and Australian smelt (*Retropinna semoni*).	By 2030, maintain self-sustaining populations of carp gudgeon (*Hypseleotris* spp.), flathead gudgeon (*Philypnodon grandiceps*) and Australian smelt (*Retropinna semoni*) at Bidgee Lagoons (Narrung Wetlands), Murrumbidgee Junction. Measured as: • Adults or YoY for each species recorded in 8 out of 10 years
MJ5: By 2030, improve vital habitat at Bidgee Lagoons (Narrung Wetlands), Murrumbidgee Junction by increasing the diversity of aquatic macrophytes present across a range of Water Regime Indicators Groups.	By 2030, increase diversity of native of macrophytes at Bidgee Lagoons (Narrung Wetlands), Murrumbidgee Junction, with ≥2 species from each of the following Water Regime Indicator Groups present in 80% of years: • Aquatic (obligate submerged) (Aos) (no species recorded) • Aquatic (submerged to partially emergent) (Ase) (no species recorded) • Aquatic graminoids (persistent) (Agp) (no species recorded) • Aquatic to semi-aquatic (persistent) (Asp) (common blown-grass *Lachnagrostis filiformis s.l.*, narrow-leaf nardoo *Marsilea costulifera*, common nardoo *Marsilea drummondii*, spiny mud-grass *Pseudoraphis spinescens*) • Seasonally immersed – low growing (Slg) (Lesser Joyweed *Alternanthera denticulata s.s.*, native couch *Cynodon dactylon var. pulchellus*, yellow twin-heads *Eclipta platyglossa subsp. Platyglossa*, common spike-sedge *Eleocharis acuta*, poison pratia *Lobelia concolor*, narrow-leaf dock *Rumex tenax*, tall fireweed *Senecio runcinifolius*, rat-tail couch *Sporobolus mitchellii*, river bluebell *Wahlenbergia fluminalis*) • Seasonally inundated – emergent non woody (Sen) (Warrego summer-grass *Paspalidium jubiflorum*, southern cane-grass *Eragrostis infecunda*, spiny flat-sedge *Cyperus gymnocaulos*)

7.3 REGIONAL SIGNIFICANCE

Murrumbidgee Junction supports environmental and Indigenous cultural heritage values of local, regional and basin significance. These values are linked to the management goals and environmental objectives and targets described in Section 7. Details of the links between the environmental objectives and environmental outcomes at a regional/Basin scale are provided in Appendix 7.

Murrumbidgee Junction 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. 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 small-bodied and juvenile large-bodied native fish when inundated.

The Mallee Waterway Strategy (2014) identifies Bidgee Lagoons (Narrung Wetlands) as high priority wetlands in the Mallee CMA region. The management goals and environmental objectives for Murrumbidgee Junction are aligned with the goals of the Mallee Waterway Strategy (2014) as described in Section 7.1. More broadly, the environmental objectives for Murrumbidgee Junction are aligned with the Murray-Darling Basin Plan, as described below in Section 7.4.

7.4 ALIGNMENT TO BASIN PLAN

The primary environmental outcome of the Basin Plan is the protection and restoration of water-dependent ecosystems and ecosystem functions in the Murray-Darling Basin, with strengthened resilience to a changing climate. The MDBA is required to measure progress towards achieving the objectives of the Environmental Watering Plan (EWP) (Chapter 8 of the Basin Plan) by using the targets in Schedule 7 and having regard to the long-term average sustainable diversion limits, ecological objectives and ecological targets. These are set out in Long-Term Watering Plans (LTWP), the Basin-wide Environmental Watering Strategy (BWS) and annual Basin environmental watering priorities.

Details on the alignment of the updated Murrumbidgee Junction EWMP environmental objectives to the Basin Plan are provided in Table 12. The mapping of objectives to Schedule 7 targets, the BWS and LTWP are provided by Butcher et al., 2020, and in Appendix 7.

Table 12. Mapping of Murrumbidgee Junction environmental objectives to Basin Plan objectives.

EWMP Objective	Alignment with Basin Plan Objectives		
	8.05 Ecosystem and biodiversity	**8.06** Ecosystem function	**8.07** Ecosystem resilience
MJ1b: By 2030, improve condition and maintain extent from baseline levels of river red gum (*Eucalyptus camaldulensis*) to sustain communities and processes reliant on mature river red gum at Bidgee Lagoons (Narrung Wetlands), Murrumbidgee Junction	8.05, 3(b)	n/a	n/a
MJ3: By 2030, improve condition and maintain extent from baseline levels of lignum (*Duma florulenta*) to sustain communities and processes reliant on lignum communities at Wakool Creek, Murrumbidgee Junction.	8.05, 3(b)	8.06, 6(b)	n/a
MJ4: By 2030, protect and restore biodiversity by maintaining representative populations of small-bodied native fish at Bidgee Lagoons (Narrung Wetlands) Murrumbidgee Junction, including carp gudgeon (*Hypseleotris* spp.), flathead gudgeon (*Philypnodon grandiceps*) and australian smelt (*Retropinna semoni*).	n/a	8.06, 6(a)	n/a
MJ5: By 2030, improve vital habitat at Bidgee Lagoons (Narrung Wetlands), Murrumbidgee Junction by increasing the diversity of aquatic macrophytes present across a range of Water Regime Indicators Groups.	8.05, 3(b)	8.06, 6(b)	n/a

8 Environmental Water Requirements and Intended Water Regime

The management objectives at Murrumbidgee Junction focus on providing a flow regime that more closely reflects natural events, to improve the capacity of the target area to support regeneration and provide a productive ecosystem for native flora and fauna.

River red gum are the structural dominant species within and along the fringes of Bidgee Lagoons (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 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.

8.1 WATERING REQUIREMENTS AND INTENDED WATERING REGIME

The wetland water requirements and intended watering regime have been derived from the environmental 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 every three years to promote large lignum shrubs with vigorous canopy. Allow water levels to draw down naturally.

The intended watering regime for the Murrumbidgee Junction is shown in Table 13.

Table 13. Intended watering regime for the Murrumbidgee Junction target area

Environmental Objective	Water management area	Mean frequency of events (No. events per 10 years)			Tolerable interval between events (years)		Duration of ponding (months)			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)
		Min	Opt.	Max	Min	Max	Min.	Opt.	Max.					
MJ1b: By 2030, improve condition and maintain extent from baseline levels of river red gum (*Eucalyptus camaldulensis*) to sustain communities and processes reliant on mature river red gum at Bidgee Lagoons (Narrung Wetlands), Murrumbidgee Junction	Bidgee Lagoons (Narrung Wetlands)	2	3	5	1	7	2	3	4	Spring/ Summer	54.4	1,083*	250**	1,333
MJ3: By 2030, improve condition and maintain extent from baseline levels of lignum (*Duma florulenta*) to sustain communities and processes reliant on lignum communities at Wakool Creek, Murrumbidgee Junction.	Wakool Creek	1	3	5	1	10	2	4	6	Spring/ Summer	55.4	201.3*		201.3*
MJ4: By 2030, protect and restore biodiversity by maintaining representative populations of small-bodied native fish at Bidgee Lagoons (Narrung Wetlands) Murrumbidgee Junction, including carp gudgeon (*Hypseleotris* spp.), flathead gudgeon (*Philypnodon grandiceps*) and Australian smelt (*Retropinna semoni*).	Bidgee Lagoons (Narrung Wetlands)	8	10	10	1	2	12	12	12	N/A	52.1	1,083*	250**	1,333
MJ5: By 2030, improve vital habitat at Bidgee Lagoons (Narrung Wetlands), Murrumbidgee Junction by increasing the diversity of aquatic macrophytes present across a range of Water Regime Indicators Groups.	Bidgee Lagoons (Narrung Wetlands)	2	5	10	0	0	1	6	12	Winter/ Spring	52.5	1,083*	250**	1,333

* Volume estimated from LiDAR **Volume estimated from past watering activities

8.2 EXPECTED WATERING EFFECTS

This section aims to explicitly outline potential watering actions to achieve the stated environmental objectives, and expected watering effects, which are shown in Table 14.

Table 14. Potential watering actions and expected watering effects

Objective code	Environmental Objective	Potential Watering Action	Expected Watering Effect
MJ1b	By 2030, improve condition and maintain extent from baseline levels of river red gum (*Eucalyptus camaldulensis*) to sustain communities and processes reliant on mature river red gum at Bidgee Lagoons (Narrung Wetlands), Murrumbidgee Junction	Facilitate regular inundation of Bidgee Lagoons (Narrung Wetlands) approximately every three years to a height of 54.4 m AHD during Spring / Summer. Maintain ponding for 3 months. Allow water to recede during Autumn / Winter.	Condition and extent of river red gum is improved or maintained from baseline levels
MJ3	By 2030, improve condition and maintain extent from baseline levels of lignum (*Duma florulenta*) to sustain communities and processes reliant on lignum communities at Wakool Creek, Murrumbidgee Junction.	Approximately every 3 years, Inundate Wakool Creek to a height of 55.4 m AHD over Spring/Summer. Maintain ponding for 5 months. Allow water to recede over Autumn/Winter.	Condition and extent of lignum and lignum communities is maintained or improved from baseline levels.
MJ4	By 2030, protect and restore biodiversity by maintaining representative populations of small-bodied native fish at Bidgee Lagoons (Narrung Wetlands) Murrumbidgee Junction, including carp gudgeon (*Hypseleotris* spp.), flathead gudgeon (*Philypnodon grandiceps*) and australian smelt (*Retropinna semoni*).	Maintain suitable depth (52.1 m AHD) in Bidgee Lagoons (Narrung Wetlands), year round. Variability in wetland inundation level is to be provided through watering actions for MJ1b and MJ5.	Areas of exposed sediments are inundated, with corresponding increases in zooplankton abundance and available vegetation. The timing of inundation coincides with, and supports fish breeding. Exposed sediments around the fringe of the wetland allow for consolidation of sediments and germination of terrestrial plants to provide cover and spawning substrate for later inundation.
MJ5	By 2030, improve vital habitat at Bidgee Lagoons (Narrung Wetlands), Murrumbidgee Junction by increasing the diversity of aquatic macrophytes present across a range of Water Regime Indicators Groups.	Approximately every second year, inundate Bidgee Lagoons (Narrung Wetlands) to 52.5 m AHD during Winter / Spring. Maintain ponding for six months. All water to recede during Summer / Autumn	Suitable conditions are provided for germination, growth and reproduction of a variety of aquatic macrophytes, through variation of water levels

8.3 SEASONALLY ADAPTIVE APPROACH

To allow for adaptive and integrated management, the watering requirements have been framed using an adaptive approach which identifies priorities for environmental watering under different seasonal conditions. This means that a watering regime is identified for optimal conditions, as well as the maximum and minimum tolerable watering scenarios. The planning scenarios under different seasonal conditions for Murrumbidgee Junction are described in Figure 11. The example watering actions presented in Figure 11 are indicative of the actions that may be delivered under the various planning scenarios. Other factors such as the condition of the site, recent watering history and forecast water availability will also influence the watering actions that are delivered.

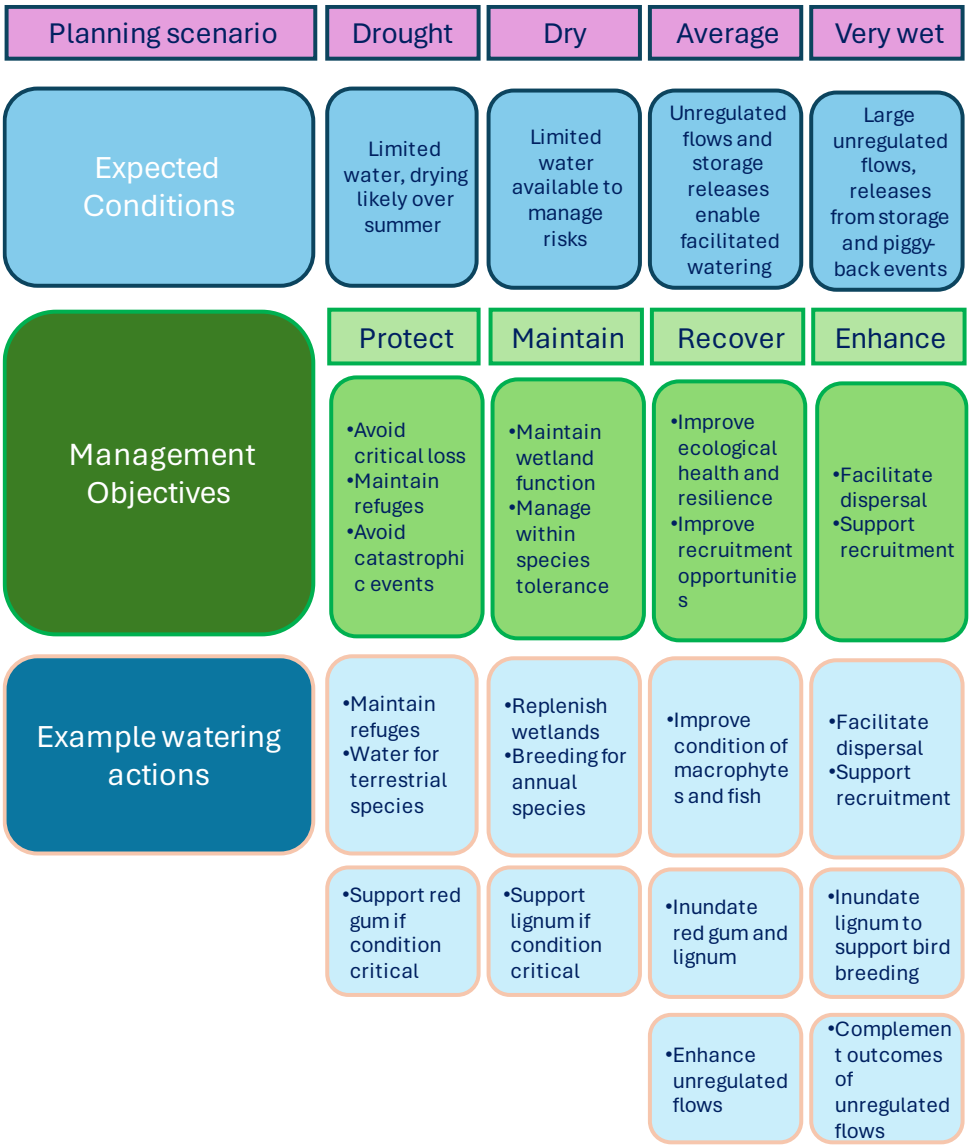


Figure 11. Indicative seasonally adaptive approach

9 Environmental Water Delivery Infrastructure

9.1 WATER DELIVERY INFRASTRUCTURE

Environmental water is currently delivered to Murrumbidgee Junction and Wakool Creek from the River Murray via temporary pumps.

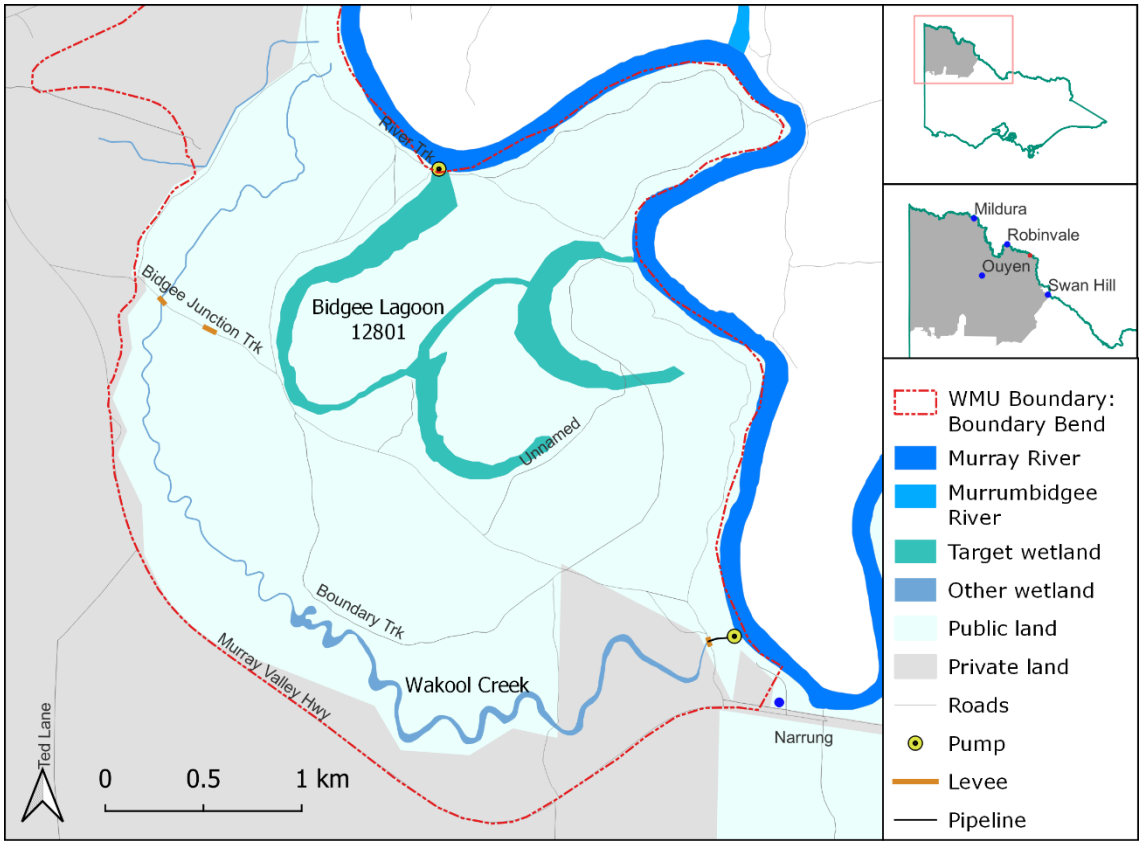


Figure 12. Infrastructure at Murrumbidgee Junction

9.2 CONSTRAINTS

The delivery of environmental water to Bidgee Lagoons (Narrung Wetlands) and Wakool Creek is not currently constrained. The lack of regulators and stop banks limits the ability of managers to retain pumped water on the Murrumbidgee Junction target area for the recommended duration.

10 Demonstrating Outcomes

10.1 ENVIRONMENTAL MONITORING

The proposed monitoring activities for the Murrumbidgee Junction target area, and links between stated objectives and monitoring priorities are shown in Table 15. These activities will enable environmental water managers to assess progress against targets and assist in the adaptive management of the target area to achieve the stated environmental objectives and outcomes.

Table 15. Environmental monitoring at the Murrumbidgee Junction target area

Objective	Monitoring Focus	Monitoring Question	Method	When
Overarching management goal	Wetland condition	Has there been an overall improvement in the condition of the target area by 2030?	Undertake IWC method	Every five years
	River red gum condition and extent	See for MJ1b	See for MJ1b	See for MJ1b
Water Regime	Volume	How much water has been delivered and retained in Lake	Lower Murray Water	Annually
	Inundation extent	Areas of each components inundated	Sentinel 2	Annually
	Maximum Depth (AHD & depth classes)	When filled, to what height (AHD) and what was area of key depth classes?	CSIRO, MDBA inundation products	Annually
	Minimum Depth (AHD & depth classes)	What was the minimum depth of the residual pool and what was its extent?	Sentinel 2	Annually
MJ1b	Condition and extent of river red gum	Is the condition of river red gum improving? What is the extent of river red gum compared to the baseline? Are new trees being recruited into the forest and woodland populations?	TSC tool, field assessments. Evaluate survival of seedlings over a 15 year period, transect survey and Tree Condition Index (TCI) score assessments, photo point monitoring, remote sensing. Compare results against benchmark of initial survey.	Annually

Objective	Monitoring Focus	Monitoring Question	Method	When
MJ3	Condition and extent of lignum	What is the baseline extent of lignum? Has the extent of lignum changed with environmental watering? Has the condition of lignum improved with environmental watering? By 2030, are ≥70% of lignum plants in good conditions, with a lignum condition score of ≥4?	Undertake lignum population monitoring using standardised transects that span the floodplain elevation gradient and existing spatial distribution, or remote sensing. Photo point monitoring. Compare results against benchmark of initial survey.	Every three years
MJ4	Abundance and diversity of populations of small bodied native fish	Are populations of small-bodied fish (gudgeon spp. and Australian smelt) present at Murrumbidgee Junction (with young-of-year recorded in 8 of 10 years)?	Undertake fish surveys targeting small-bodied native fish.	Annually
MJ5	Diversity of aquatic macrophytes from across a range of Water Regime Indicators groups	What is the distribution and species composition of aquatic vegetation? By 2030 Are ≥2 species from each of the Water Regime Indicator groups present in 80% of years?	Undertake surveys of aquatic macrophytes at Murrumbidgee Junction (including species ID and extent). Compare results against benchmark of initial survey.	Every three years

10.2 MONITORING PRORITIES AT THE ASSET

The monitoring priorities that have been identified for the Murrumbidgee Target area and reason for their prioritisation are shown in Table 16.

Table 16. Monitoring priorities at Murrumbidgee Junction

Monitoring Priority	Reason for Priority
Water delivery	Adaptive management: water is managed to meet EWMP objectives.
Index of wetland condition assessments	These provide information on changes in hydrology and water quality that impact on flora and fauna.
River red gum condition and extent	To develop baselines to assist condition assessments. Key for assessing progress against objectives of the Basin Plan Environmental Watering Plan (EWP), Basin Plan Schedule 7 targets, Basin wide Environmental Watering strategy (BWS) and Victorian Murray Long Term Watering Plan.

Monitoring Priority	Reason for Priority
Lignum condition and extent	To develop baselines to assist condition assessments. Key for assessing progress against objectives of the Basin Plan Environmental Watering Plan (EWP), Basin Plan Schedule 7 targets, Basin wide Environmental Watering strategy (BWS) and Victorian Murray Long Term Watering Plan.
Abundance and diversity of small-bodied native fish	To develop baselines to assist condition assessments and to understand drivers of variation. Key for assessing progress against objectives of the Basin Plan Environmental Watering Plan (EWP), Basin Plan Schedule 7 targets, Basin wide Environmental Watering strategy (BWS) and Victorian Murray Long Term Watering Plan.
Diversity of aquatic macrophytes	To develop baselines to assist condition assessments and to understand drivers of variation. Key for assessing progress against objectives of the Basin Plan Environmental Watering Plan (EWP), Basin Plan Schedule 7 targets, Basin wide Environmental Watering strategy (BWS) and Victorian Murray Long Term Watering Plan.

11 Adaptive Management

Mallee CMA uses an adaptive management approach in planning and managing environmental watering actions.

Adaptive management is the process of incorporating new scientific and operational information into the implementation of a project or plan to ensure that management actions are appropriate, effective and contribute to goals efficiently. It is a standard and well-established practice for environmental water management, recognising the inherent uncertainties and risks associated with the complex relationships between changes to hydrology and ecological responses, and the potential for a watering event to provide both positive and adverse outcomes. Figure 13 shows an illustration of the adaptive management cycle for environmental water delivery.

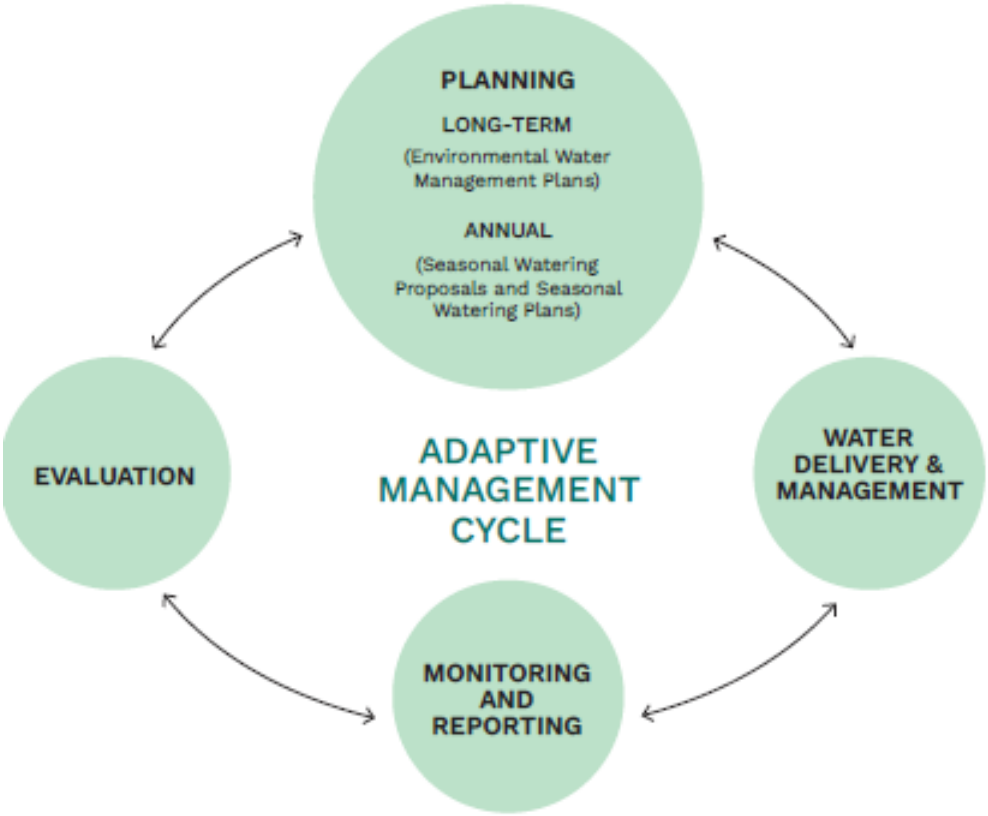


Figure 13. The adaptive management cycle for environmental water delivery and management

Mallee CMA uses three main pathways to identify inputs to the adaptive management process (also referred to as lessons):

- monitoring to detect differences between what was planned and the outcomes at the environmental watering site
- incidental observations by managers, operators or other observers that identify opportunities to reduce risk or improve outcomes
- research or investigations into hydraulic or ecological management practices that could improve the conceptual models on which operations are based.

Mallee CMA formally documents lessons to strengthen organisational memory and provide transparency in continual improvement measures. Recording of lessons is crucial for both annual environmental watering actions and long-term planning. Demonstrating continual improvement provides the justification for monitoring programs and confirms that assets are being managed responsibly.

An adaptive management framework has several components that work together to build lessons learned from environmental watering actions and program partners into the environmental water program. This produces iterative improvements in the way environmental watering is undertaken using the best available evidence. The EWMP will be constantly refined to incorporate learnings from ecological monitoring as well as feedback from community consultation.

Land managers and river operators are included in the operational planning cycle which include adaptive management processes to incorporate learnings and risk management.

Figure 14. Murrumbidgee Junction, water present in 3rd Lagoon. Source: Mallee CMA.

12 Knowledge gaps and recommendations

This plan is based on best information at the time of writing. In some cases, information is scarce or outdated. Further investigation and information collection will continue, and the results of this further work will continue to build a better picture of the site and add rigor to future planning. Some areas where further knowledge would be beneficial are outlined in Table 17. Any future monitoring plan could include a number of these recommendations.

Table 17. Knowledge gaps and recommendations for Murrumbidgee Junction

Knowledge and data gaps	Action recommended	Responsibility
Mechanism to achieve recommended watering regime at Murrumbidgee Junction	Scoping of infrastructure requirements and detailed design of options for watering Wakool Creek. Note, detailed design of a regulator at Bidgee Lagoons (Narrung Wetlands) was completed in 2011.	Implementation of any of these recommendations would be dependent on investment from Victorian and Australian Government funding sources as projects managed through the Mallee CMA
Wetland condition	Bidgee Lagoons (Narrung Wetlands) should be incorporated into the five-yearly Index of Wetland Condition assessments.	
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, including small bodied native fish	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.	
Condition and extent of river red gum, lignum and aquatic macrophytes	Undertake methods identified in Table 15.	
Groundwater and salinity interactions	Groundwater and salinity interaction assessments should be undertaken.	
Cultural Heritage Assessments and Cultural Mapping	Traditional Owners to carry out Cultural values assessment at site to understand cultural constraints to watering.	

13 References

ACHRIS 2024. Aboriginal Cultural Heritage Register and Information System. Available at: https://achris.vic.gov.au/#/dashboard

Alluvium, 2011. *Detail Design Report: Murrumbidgee Junction Wetlands Watering*. Mildura, Victoria: Mallee CMA.

Australian Bureau of Statistics 2021. *2021 Census data for Boundary Bend*. Available at: https://www.abs.gov.au/census/find-census-data/search-by-area

Baker-Gabb, D. and Hurley, V.., 2011. *National Recovery Plan for the Regent Parrot (eastern subspecies)*. East Melbourne, Victoria: Department of Sustainability and Environment.

Bell, J., 2012. *Construction of three regulator structures at Bidgee Lagoons (Narrung Wetlands), near Boundary Bend Cultural Heritage Management Plan. Report for the Mallee CMA*. Jo Bell Heritage Services Pty Ltd.

Butcher, R., Cottingham, P. and Fenton, A. (2020) *Briefing paper: Update of Mallee EWMP objectives*, Report prepared by Water's Edge Consulting for Mallee Catchment management Authority, Mooroolbark, Victoria.

Cheal, D., Lucas, A. and Macaulay, L., 2011. *National Recovery Plan for Buloke Woodlands of Riverina and Murray-Darling Depression Bioregions*. East Melbourne, Victoria: Department of Sustainability and Environment.

DCCEEW 2023. *Protected Matters Search Tool* (online). Available at: https://www.dcceew.gov.au/environment/epbc/protected-matters-search-tool

DEECA 2023. NatureKit website, available at: https://maps2.biodiversity.vic.gov.au/Html5viewer/index.html?viewer=NatureKit

DELWP, 2015. *Index of Condition System*. Available at: <http://ics.water.vic.gov.au/ics/> [Accessed 22 Oct. 2015].

DELWP 2022. *Environmental Water Management Plan Guidelines for Rivers and Wetlands (Version 6)*. The State of Victoria Department of Environment, Land, Water and Planning 2022

DEPI, 2015. *EVC benchmarks*. EVC benchmarks. Available at: http://www.depi.vic.gov.au/environment-and-wildlife/biodiversity/evc-benchmarks [Accessed 28 Oct. 2015].

DNRE, 1997. *Victoria's Biodiversity- Our Living Wealth - Sustaining Our Living Wealth and Directions in Management*. Melbourne, Victoria: Department of Natural Resources and Environment.

DSE, 2003a. *Action Statement; Inland Carpet Python, Morelia spilota metcalfei*. East Melbourne, Victoria: Department of Sustainability and Environment.

DSE, 2004. *EVC Bioregion Benchmark for Vegetation Quality Assessment. Murray Mallee Bioregion.* East Melbourne, Victoria: Department of Sustainability and Environment.

DSE, 2005. *EVC Bioregion Benchmark for Vegetation Quality Assessment. Murray Fans Bioregion.* East Melbourne, Victoria: Department of Sustainability and Environment.

Ecological Associates, 2006. *Investigation of Water Management Options for the Murray River – Nyah to Robinvale*. Mildura, Victoria: Report prepared for Mallee Catchment Management Authority.

Ecological Associates, 2007. *Feasibility investigation of options for Hattah Lakes, Final Report*. Mildura, Victoria: Report prepared for Mallee Catchment Management Authority.

Kingsford, R.T. and Norman, F.I., 2002. Australian waterbirds - products of the continent's ecology. *Emu*, (102), pp.47–69.

LCC, 1989. *Mallee Area Review Final Recommendations*. Melbourne, Victoria: Land Conservation Council.

Loyn, R., Lumsden, L. and Ward, K., 2002. Vertebrate fauna of Barham forest, a large forest of River Red Gum Eucalyptus camaldulensis on the floodplain of the Murray River. *The Victorian Naturalist*, 119(3), pp.114–124.

Maheshwari, B.L., Walker, K.F. and McMahon, T.A., 1993. *The impact of flow regulation on the hydrology of the River Murray and its ecological implications*. Centre for Environmental Applied Hydrology, Department of Civil and Agricultural Engineering, the University of Melbourne and River Murray Laboratory, Department of Zoology, University of Adelaide.

Mallee CMA, 2003. *Murray River Frontage Action Plan –Robinvale to Merbein Common*. Mildura, Victoria: Mallee CMA.

Mallee CMA 2014. Mallee Waterway Strategy 2014-2022. Document Set ID: 6818. Mallee Catchment Management Authority 2014.

North, L., 2014. *Regional context document for environmental water management plans.* Final report prepared for the Mallee CMA by Sunraysia Environmental.

Purdey, D. and Loyn, R., 2008. *Wetland use by Blue-billed Ducks Oxyura australis during Summer Waterfowl Counts in North-West Victoria, 1984-2008*. Heidelberg, Victoria: Arthur Rylah Institute for Environmental Research.

Roberts, J. and Marston, F., 2011. *Water Regime for Wetland and Floodplain Plants; a source book for the Murray-Darling Basin.* Canberra, ACT: National Water Commission.

Robertson, P. and Hurley, V.., 2001. *Investigation of potential riverine habitat for the Inland Carpet Python (Morelia spilota metcalfei) in the Mildura Forest Management Area*.

Robertston, A.I., Bacon, P. and Heagney, G., 2001. The responses of floodplain primary production to flood frequency and timing. *Journal of Applied Ecology*, (38), pp.126–136.

Rogers, K. and Ralph, T.J., 2011. *Floodplain wetland biota: in the Murray-Darling basin ; water and habitat requirements*. Collingwood: CSIRO Publishing.

Roshier, D.A., Robertston, A.I. and Kingsford, R.T., 2002. Responses of waterbirds to flooding in an arid region of Australia and implications for conservation. *Biological Conservation*, (106), pp.399–411.

SKM, 2009. *Ecological Objectives for the Euston Weir*. Department of Water and Energy, NSW.

Thoms, M.C., Suter, P., Roberts, J., Koehn, J., Jones, G., Hillman, T. and Close, A., 2000. *Report of the River Murray Scientific Panel on environmental flows: River Murray - Dartmouth to Wellington and the Lower Darling River*. Canberra, ACT: River Murray Scientific Panel on Environmental Flows, Murray-Darling Basin Commission.

VEAC, 2008. *Identifying flood-dependent natural values on the Victorian floodplains of the River Murray and its tributaries*. East Melbourne, Victoria: Victorian Environmental Assessment Council.

Vestjen, W., 1975. Breeding behaviour of the Darter at Lake Cowal, NSW. *Emu*, (75), pp.121–131.

Young, W.J., 2001. *Rivers as ecological systems: the Murray-Darling Basin*. Canberra, ACT: Murray-Darling Basin Commission.

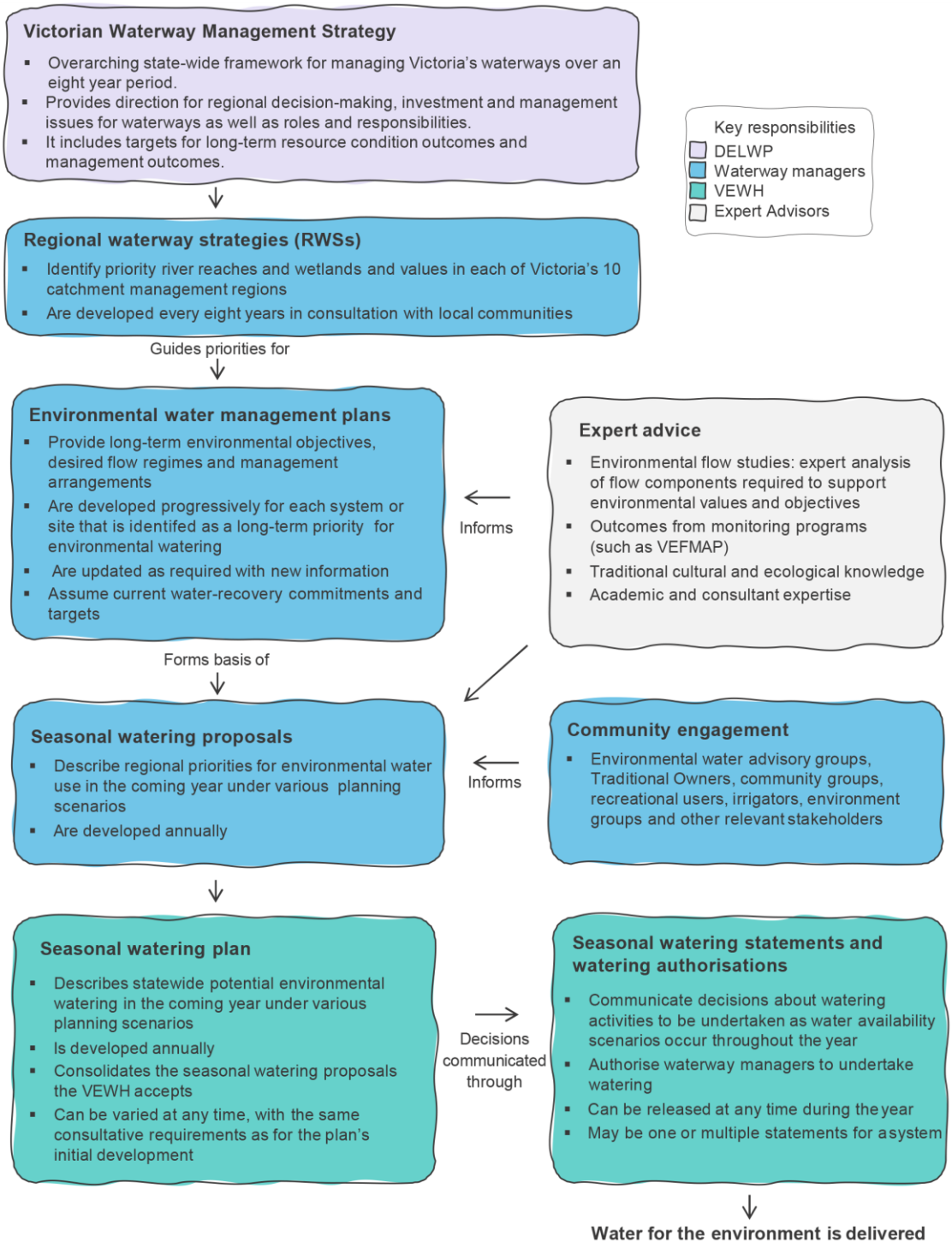
APPENDIX 1.

Environmental Water Management Plan Context

Environmental water in Victoria is managed as an integral part of the Victorian Waterway Management Program. The state-level Victorian Waterway Management Strategy (VWMS) provides the overarching framework for environmental water management (see accompanying figure). The Mallee Waterway Strategy (2014-22) drives implementation of the VWMS at the regional level. Information from the Mallee Waterway Strategy is a key input to environmental water planning arrangements, including the selection of eligible assets to receive environmental water. Environmental water management plans are site-specific plans developed for a wetland or wetland complex deemed a priority to receive environmental water through the Mallee Waterway Strategy development process. This document is the Environmental Water Management Plan (EWMP) for Murrumbidgee Junction in the Mallee Catchment Management region.

Environmental watering in the Mallee Region has historically been supported by management plans such as this one, that document key information including the watering requirements of an asset, predicted ecological responses and water delivery arrangements. These plans support annual decisions about which sites should receive water and assist managers to evaluate how well those assets respond to the water they receive or what could be done better. Environmental water management at Murrumbidgee Junction is further underpinned by the Murray-Darling Basin Plan 2012 (Commonwealth) and the associated Basin-wide environmental watering strategy. In accordance with Basin Plan requirements, Victoria has also developed the Victorian Murray Water Resource Plan and Victorian Murray Long-Term Watering Plan, which apply at Murrumbidgee Junction.

Mallee Catchment Management Authority (MCMA), the Victorian Department of Energy, Environment and Climate Action (DEECA), the Victorian Environmental Water Holder (VEWH) and Traditional Owner groups have worked together to develop several EWMPs for watered assets throughout the Mallee region. These plans are continually updated through an adaptive management process. A primary purpose of EWMPs is to provide a consistent set of documents that support seasonal watering proposals to be submitted by asset managers to the VEWH annually.



EWMP Policy Context

APPENDIX 2.

COMMUNITY AND AGENCY ENGAGEMENT 2024

Community stakeholders were engaged on the update of this and other EWMPs in person at several local events, including local markets (Mildura Market, Red Cliffs Market, Swan Hill Market), local environmental group meetings (Mildura Birdlife meeting, Greening Mildura meeting, Cabarita Inc. day and an environmental volunteer event), and a drop in event at Nangiloc. In-person engagements were designed to enable community input to the plans, and included a 'Pins in Maps' exercise, where stakeholders identified locations of water-dependent values at WMU subunits.

Community stakeholders were also engaged on the update of the Murrumbidgee Junction EWMP via an online survey, which was hosted on the Mallee CMA website in December 2023 – January 2024. The survey and in-person engagements supplement earlier community engagement about the Murrumbidgee Junction EWMP, and annual community engagement that informs the Seasonal Watering Proposal (SWP). Community consultation occurs at the IAP2 level of CONSULT.

In person engagement:

No specific information on Murrumbidgee Junction was provided by community stakeholders at in-person engagements.

Online Survey:

One respondent completed the online survey for Bidgee Lagoons (Narrung Wetlands). The respondent was a recreational user who visited the site once or twice per year, in any season, for work. The respondent strongly agreed with the return of natural watering cycles to Bidgee Lagoons (Narrung Wetlands).

In-person Traditional Owner engagement:

Traditional Owner representatives were engaged on the Murrumbidgee Junction EWMP at an in-person meeting on-Country at Wakool Creek in November 2023. Representatives from Culpra Milli Aboriginal Corporation, Gilbie Aboriginal Corporation, Munatunga Elders, Tati Tati Land and Water Indigenous Corporation, Wadi Wadi Nation, Tati Tati Wadi Wadi Land and Water Indigenous Corporation, and Dadi Dadi Weki Weki Aboriginal Corporation attended the engagement. Representatives discussed cultural and ecological values at the site, cultural heritage (burials, shell midden and artefacts) and the relatively good condition of the site compared to other nearby wetlands.

Agency Engagement:

Mallee CMA met with representatives from agency stakeholders Parks Victoria, Lower Murray Water and Mildura Rural City Council in February 2024. Discussions for Murrumbidgee Junction centred on the need for cultural heritage inspections at the site.

APPENDIX 3.

ECOLOGICAL VEGETATION CLASSES (EVCS)

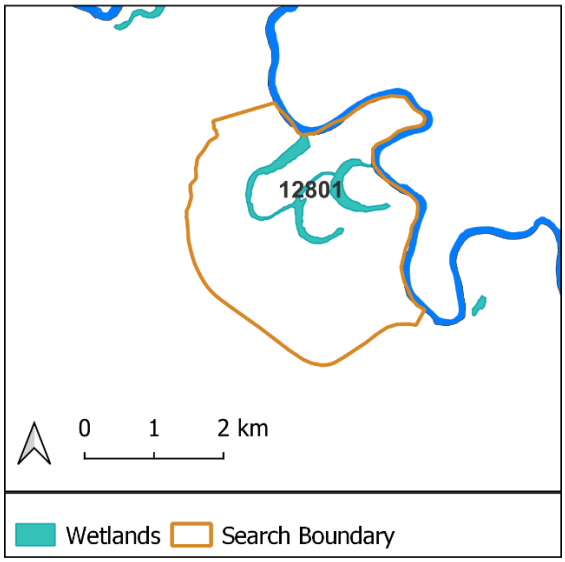
EVC No.	EVC name	Bioregional conservation status		Description
		Murray Fans	Murray Mallee	
86	Woorinen Sands Mallee	Depleted	Depleted	Mallee shrubland to 7 m tall, typically supporting a hummock grass (*Triodia spp*.) dominated understorey. This EVC could be considered intermediate between the heavier 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.

EVC No.	EVC name	Bioregional conservation status		Description
		Murray Fans	Murray Mallee	
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: NatureKit (DEECA 2023); DSE, 2004, 2005)

APPENDIX 4.

FAUNA SPECIES LIST

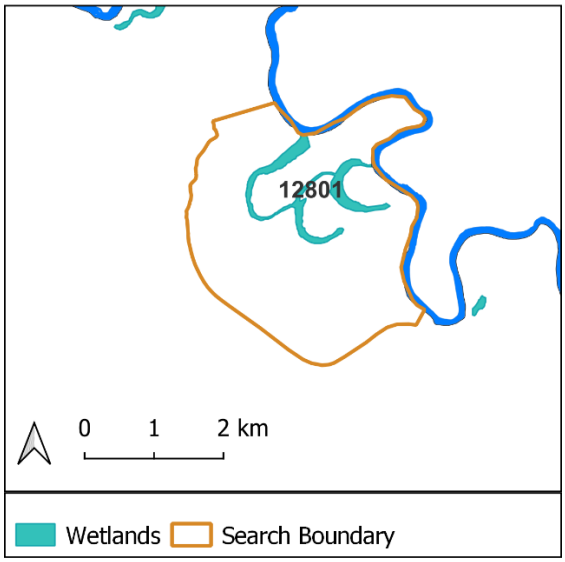


Scientific Name	Common Name	FFG Act	EPBC Act	Source
Chenonetta jubata	Australian wood duck	-	-	NatureKit
Morelia spilota metcalfei	Carpet python	Endangered	-	NatureKit
Pomatostomus ruficeps	Chestnut-crowned babbler	-	-	NatureKit
Phaps chalcoptera	Common bronzewing	-	-	NatureKit
Platycercus elegans	Crimson rosella	-	-	NatureKit
Dromaius novaehollandiae	Emu	-	-	NatureKit
Eolophus roseicapilla	Galah	-	-	NatureKit
Colluricincla harmonica	Grey shrike-thrush	-	-	NatureKit
Cacatua sanguinea	Little corella	-	-	NatureKit
Maccullochella peelii	Murray cod	Vulnerable	Endangered	Protected matters search tool
Cracticus nigrogularis	Pied butcherbird	-	-	NatureKit
Petroica goodenovii	Red-capped robin	-	-	NatureKit
Pachycephala rufiventris	Rufous whistler	-	-	NatureKit
Ninox boobook	Southern boobook	-	-	NatureKit
Cacatua galerita	Sulphur-crested cockatoo	-	-	NatureKit
Malurus cyaneus	Superb fairy-wren	-	-	NatureKit
Hirundo neoxena	Welcome swallow	-	-	NatureKit
Haliastur sphenurus	Whistling kite	-	-	NatureKit
Ardea pacifica	White-necked heron	-	-	NatureKit
Ptilotula penicillata	White-plumed honeyeater	-	-	NatureKit

(Source: DEECA 2023, Protected matters search tool, DCCEEW 2023)

APPENDIX 5.

FLORA SPECIES LIST (SOURCE: DEECA NATUREKIT 2023)



Scientific Name	Common Name	FFG Act Status	EPBC Act Status
Gemmabryum pachytheca	Acorn-fruited thread-moss	-	-
Symphyotrichum subulatum	Aster-weed*	-	-
Ajuga australis	Austral bugle	-	-
Lotus australis	Austral trefoil	-	-
Osteocarpum acropterum var. deminutum	Babbagia	-	-
Phascum robustum var. robustum	Ball moss	-	-
Eucalyptus largiflorens	Black box	-	-
Solanum nigrum s.l.	Black nightshade*	-	-
Sclerolaena muricata	Black roly-poly	-	-
Maireana spp.	Bluebush	-	-
Amyema miquelii	Box mistletoe	-	-
Calotis spp.	Burr daisy	-	-
Plantago cunninghamii	Clay plantain	-	-
Lachnagrostis filiformis s.l.	Common blown-grass	-	-
Lachnagrostis filiformis s.s.	Common blown-grass	-	-
Heliotropium europaeum	Common heliotrope*	-	-
Marsilea drummondii	Common nardoo	-	-
Centipeda cunninghamii	Common sneezeweed	-	-
Sonchus oleraceus	Common sow-thistle*	-	-
Eleocharis acuta	Common spike-sedge	-	-
Asteraceae spp.	Composite	-	-
Senecio quadridentatus	Cotton fireweed	-	-
Centipeda nidiformis	Cotton sneezeweed	Endangered	-
Cynodon dactylon	Couch^	-	-

Scientific Name	Common Name	FFG Act Status	EPBC Act Status
Plantago turrifera	Crowned plantain	-	-
Fissidens megalotis	Curly pocket-moss	-	-
Crassula colorata	Dense crassula	-	-
Vittadinia dissecta s.l.	Dissected New Holland daisy	-	-
Leichhardtia australis	Doubah	Endangered	-
Swainsona phacoides	Dwarf swainson-pea	Endangered	-
Ephemerum cristatum	Earth moss	-	-
Bryobartramia novae-valesiae	Earth moss	-	-
Acacia stenophylla	Eumong^	-	-
Ranunculus pumilio var. pumilio	Ferny small-flower Buttercup	-	-
Juncus subsecundus	Finger rush	-	-
Actinobole uliginosum	Flannel cudweed	-	-
Euphorbia drummondii s.l.	Flat spurge^	-	-
Hypochaeris radicata	Flatweed*	-	-
Erigeron bonariensis	Flaxleaf fleabane*	-	-
Phyla nodiflora var. minor	Fog-fruit*	-	-
Vittadinia cuneata	Fuzzy New Holland daisy	-	-
Oxalis perennans	Grassland wood-sorrel	-	-
Cullen discolor	Grey scurf-pea	Endangered	-
Calotis hispidula	Hairy burr-daisy	-	-
Herniaria cinerea	Hairy rupture-wort*	-	-
Rhagodia spinescens	Hedge saltbush^	-	-
Rorippa laciniata	Jagged bitter-cress	-	-
Laphangium luteoalbum	Jersey cudweed	-	-
Bulbine semibarbata	Leek lily	-	-
Alternanthera denticulata s.s.	Lesser joyweed	-	-
Medicago minima	Little medic*	-	-
Sisymbrium irio	London rocket*	-	-
Eragrostis spp.	Love grass	-	-
Alopecurus geniculatus	Marsh fox-tail*	-	-
Brassica tournefortii	Mediterranean turnip*	-	-
Myosurus australis	Mousetail	-	-
Rumex tenax	Narrow-leaf dock	-	-
Marsilea costulifera	Narrow-leaf nardoo	-	-
Cynodon dactylon var. pulchellus	Native couch	-	-
Vittadinia spp.	New Holland daisy	-	-
Solanum spp.	Nightshade	-	-
Chenopodium nitrariaceum	Nitre goosefoot	-	-
Nitraria billardierei	Nitre-bush	-	-
Einadia nutans	Nodding saltbush	-	-
Hordeum glaucum	Northern barley-grass*	-	-

Scientific Name	Common Name	FFG Act Status	EPBC Act Status
Calocephalus sonderi	Pale beauty-heads	-	-
Phalaris paradoxa	Paradoxical canary-grass*	-	-
Gigaspermum repens	Pineapple moss	-	-
Polycalymma stuartii	Poached-eggs daisy	-	-
Lobelia concolor	Poison pratia	-	-
Lactuca serriola	Prickly lettuce*	-	-
Opuntia spp.	Prickly pear*	-	-
Salsola tragus subsp. tragus	Prickly saltwort	-	-
Vulpia myuros f. myuros	Rat's-tail fescue*	-	-
Sporobolus mitchellii	Rat-tail couch	-	-
Lotus cruentus	Red bird's-foot trefoil	-	-
Bromus rubens	Red brome*	-	-
Spergularia rubra s.l.	Red sand-spurrey*	-	-
Galium binifolium	Reflexed bedstraw	-	-
Walwhalleya proluta	Rigid panic	-	-
Wahlenbergia fluminalis	River bluebell	-	-
Eucalyptus camaldulensis	River red-gum	-	-
Cardamine moirensis	Riverina bitter-cress	Endangered	-
Sonchus asper s.l.	Rough sow-thistle*	-	-
Enchylaena tomentosa var. tomentosa	Ruby saltbush	-	-
Enchylaena tomentosa var. tomentosa	Ruby saltbush	-	-
Tragopogon porrifolius subsp. porrifolius	Salsify*	-	-
Atriplex spp.	Saltbush	-	-
Sclerochlamys brachyptera	Short-wing saltbush	-	-
Crassula sieberiana s.l.	Sieber crassula	-	-
Goodenia fascicularis	Silky goodenia	-	-
Chondrilla juncea	Skeleton weed*	-	-
Dodonaea viscosa subsp. angustissima	Slender hop-bush	-	-
Atriplex leptocarpa	Slender-fruit saltbush	-	-
Polygonum plebeium	Small knotweed	-	-
Hypochaeris glabra	Smooth cat's-ear*	-	-
Sisymbrium erysimoides	Smooth mustard*	-	-
Eragrostis infecunda	Southern cane-grass	-	-
Cirsium vulgare	Spear thistle*	-	-
Cyperus gymnocaulos	Spiny flat-sedge	-	-
Pseudoraphis spinescens	Spiny mud-grass	-	-
Wahlenbergia gracilis	Sprawling bluebell	-	-
Atriplex suberecta	Sprawling saltbush^	-	-
Eremophila divaricata subsp. divaricata	Spreading emu-bush	Vulnerable	-
Centipeda minima subsp. minima s.s.	Spreading sneezeweed	-	-
Picris squarrosa	Squat picris	Endangered	-
Vulpia bromoides	Squirrel-tail fescue*	-	-

Scientific Name	Common Name	FFG Act Status	EPBC Act Status
Sclerolaena stelligera	Star bluebush	-	-
Dittrichia graveolens	Stinkwort*	-	-
Sclerolaena tricuspis	Streaked copperburr	-	-
Senecio runcinifolius	Tall fireweed	-	-
Duma florulenta	Tangled lignum	-	-
Brachyscome ciliaris	Variable daisy	-	-
Sida corrugata	Variable sida	-	-
Austrostipa scabra/nitida/nodosa spp. agg.	Variable spear-grass	-	-
Paspalidium jubiflorum	Warrego summer-grass^	-	-
Crassula natans var. minus	Water crassula*	-	-
Lolium rigidum	Wimmera rye-grass*	-	-
Microseris spp.	Yam daisy	-	-
Calostemma luteum	Yellow garland-lily	Endangered	-
Eclipta platyglossa subsp. platyglossa	Yellow twin-heads^	-	-

* indicates introduced species
^ indicates native species, but some stands may be alien

(Source: NatureKit, DEECA 2023)

APPENDIX 6.

ASSESSING RISKS

Assessing Risk - Consequence

Prioritising wetland watering is often difficult because there is no framework by which the fate of different species can be compared. To support prioritisation, this guide seeks to put each wetland and its associated species within a regional context. The process can also be used when communicating the rationale behind decisions or support engagement by providing a framework for discussion.

The process is presented in Figure A1, with a more detailed explanation provided in Tables A1 and A2.

Table A1.

Row	Question	Rationale	Response	Risk	Go To
1	Will the species persist *in situ*?	If the species will survive without intervention, it becomes a lower priority	Yes	Low	
			No		Row 2
2	Will the species persist in a connected refuge?	If the species has the capacity (its own capability and appropriate connectivity) to survive, it becomes a lower priority	Yes		Table A2
			No		Row 3
3	Is the species common?	If a species is common then there may be other populations that are more likely or easier to protect than the ones in the wetland.	Yes	Med	
			No	High	

Table A2

Row	Question	Rationale	Response	Risk	Go To
1	Is the species short or long lived?	Long-lived species often have greater capacity to endure periods of hardship, whereas short lived species are programmed to die.	Long	Med	
			Short		Row 2
2	Does the species need the wetland to recruit?	If the species requires the wetland to recruit then sustaining will require protection of wetland condition.	No	Med	
			Yes		Row 3
3	Is the species common?	If a species is common then there may be other populations that are more likely or easier to protect than the ones in the wetland.	Yes	Mod	
			No	High	

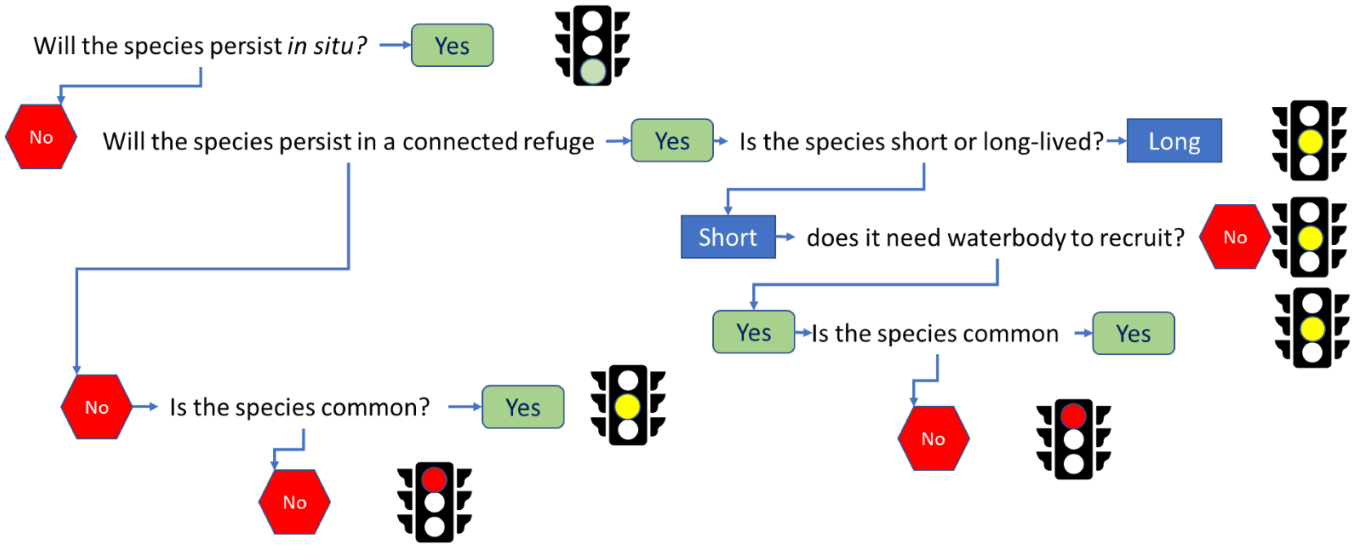


Figure A1 – Decision tree for assessing risk

APPENDIX 7.

MURRUMBIDGEE JUNCTION EWMP UPDATED ENVIRONMENTAL OBJECTIVES AND FURTHER INFORMATION (FROM BUTCHER ET AL. 2020)

5.18 Murrumbidgee Junction

5.18.1 SMARTness and rationalisation

Site-specific environmental objectives for the Murrumbidgee Junction EWMP (Riverness 2015b).

EWMP objectives
MJ1: Maintain a healthy and productive wetland woodland mosaic (particularly EVCs 809, 810,818, 200) – (Wetland area: Bidgee Lagoons (Narrung Wetlands))
MJ2: 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 – (Wetland area: Bidgee Lagoons (Narrung Wetlands))
MJ3: Promote a healthy and productive Lignum Shrubland (EVC 808) providing habitat for waterbird nesting and roosting – (Wetland area: Wakool Creek)
MJ4: Sustain resident populations of small-bodied native fish and opportunistic use by large-bodied native fish through maintenance of permanent pool habitat – (Wetland area: Bidgee Lagoons (Narrung Wetlands))
MJ5: Promote seasonal emergent and semi emergent macrophytes –– (Wetland area: Bidgee Lagoons (Narrung Wetlands))

Assessment of SMARTness of current Murrumbidgee Junction EWMP objectives. Scoring: 1 is criterion met, 0 is criterion not met, and 0.5 is partially met

	Specific		Measurable			Achievable		Relevant		Timely	
Objective	Magnitude clearly specified	Location and scale detailed	Indicators available or easily developed	Can be analysed using accepted statistical practices	Capacity to collect data exists	Under river operating constraints and current climate variability	Considered feasible by knowledgeable stakeholders	Matters driven by environmental watering and/or works and measures	Linked to BP objectives	Absolute date or time period specified	Considers likely lags in response
MJ1	0	0	1	1	1	0.5	1	1	1	0	0
MJ2	0	0	1	1	1	0.5	1	1	1	0	0
MJ3	0	0	1	1	1	0.5	1	1	1	0	0
MJ4	0	0	1	1	1	0.5	1	1	1	0	0
MJ5	0	0	1	1	1	0.5	1	1	0.5	0	0

Rationalised environmental objectives for the Murrumbidgee Junction EWMP (Riverness 2015b).

Objective	Issue	Outcome
MJ1	The vegetation objectives are a bit mixed – MJ1 is about aquatic macrophytes and RRG dominated EVCs which overlap with MJ5 and MJ2 respectively. Aquatic macrophytes are captured in MJ5 and RRG in MJ1b	Objective updated to align with Basin Plan language – split to cover WRIGs and then RRG separately. MJ1a WRIGs is combined with MJ5.
MJ2	Terrestrial biota are not relevant to environmental watering as not deemed water dependent.	Only regent parrot and WBSE are considered relevant – focus is on the condition of the RRG, not the biota per se. This objective is now covered under MJ1b
MJ3	Objective has multiple aspects (condition and productivity).	Rationalised to align with LTWP objectives with the assumption that if condition is improved this incorporates productivity.
MJ4	MCMA deleted component related to 'opportunistic use by large-bodied native fish through maintenance of permanent pool habitat'. Not primary Large-bodied fish habitat (particularly through e-water delivery)	Objective to focus on outcomes for small-bodied native fish
MJ5	No issue with objective other than its not fully SMART and no baseline data.	Objective updated to align with Basin Plan language

5.18.2 Mapping to Basin Plan

Basin Plan Schedule 8 and 9 criteria.

Schedule 8 criteria met	Schedule 9 criteria met
From DELWP (2015a)	
1: JAMBA, CAMBA **3:** Water dependent species which will benefit from the wetlands in the target area receiving water **5:** EVC 103 Riverine Chenopod Woodland - endangered, 809 Floodplain Grassy Wetland - endangered^	**1:** Supports the creation and maintenance of vital habitats and populations **2:** water quality - ecosystem processes supports the transportation and dilution of nutrients, organic matter and sediment; supports the dilution of carbon and nutrients from the floodplain to the river system **4:** lateral connectivity - (between floodplains, anabranches and wetlands)
Updated assessment	
3(b): Prevents declines in native biota	**1(d):** Vital habitat - diversity of aquatic environments **1(e):** Vital habitat - preventing decline of native biota

^ Mapping PEA criteria 5 to EVC is not appropriate

Mapping Murrumbidgee Junction EWMP objectives to Basin Plan EWP objectives, Schedule 7 targets, BWS QEEO, and LTWP Vic Murray objective.

EWMP objectives	Relevant Basin Plan EWP objective	Relevant Schedule 7 target	Relevant BWS QEEO	LTWP objective
MJ1: Maintain a healthy and productive wetland woodland mosaic (particularly EVCs 809, 810,818, 200) – (Wetland area: Bidgee Lagoons (Narrung Wetlands))	8.05,3(b)	Condition of priority asset - prevention of decline in native biota Condition of native water dependent vegetation	B2.8 B2.11	LTWPVM5 LTWPVM2
MJ2: 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 – (Wetland area: Bidgee Lagoons (Narrung Wetlands))	8.05,3(b) 8.06,6(b)	Condition of priority asset - prevention of decline in native biota Condition of native water dependent vegetation Condition of priority asset - Vital habitat - feeding, breeding, nursery	B2.2 B2.8	LTWPVM5
MJ3: Promote a healthy and productive Lignum Shrubland (EVC 808) providing habitat for waterbird nesting and roosting – (Wetland area: Wakool Creek)	8.05,3(b) 8.06,6(b)	Condition of priority asset - prevention of decline in native biota Diversity of native water dependent vegetation	B2.10	LTWPVM8

EWMP objectives	Relevant Basin Plan EWP objective	Relevant Schedule 7 target	Relevant BWS QEEO	LTWP objective
		Condition of priority ecosystem functions - creation of vital habitat - habitat for prevention of decline in native species Condition of water-dependent vegetation		
MJ4: Sustain resident populations of small-bodied native fish and opportunistic use by large-bodied native fish through maintenance of permanent pool habitat – (Wetland area: Bidgee Lagoons (Narrung Wetlands))	8.06,6(a)	Condition of priority asset - prevention of decline in native biota Recruitment and populations of native fish	B4.5	LTWPVM15
MJ5: Promote seasonal emergent and semi emergent macrophytes –– (Wetland area: Bidgee Lagoons (Narrung Wetlands))	8.05,3(b) 8.06,6(b)	Condition of priority asset - prevention of decline in native biota Diversity of native water dependent vegetation Condition of priority ecosystem functions - creation of vital habitat - habitat for prevention of decline in native species	B2.11	LTWPVM2

5.18.3 Updated objectives for Murrumbidgee Junction

Current objective	**MJ1: Maintain a healthy and productive wetland woodland mosaic (particularly EVCs 809, 810,818, 200)** – (Wetland area: Bidgee Lagoons (Narrung Wetlands))
Comments	Split into two objectives – one using WRIGs and aquatic macrophytes (EVC 200 809 810), the others focusing on RRG (218)
2020 Objective MJ1a:	See MJ5
2020 Targets MJ1a:	See MJ5
Comments	Focus of the objective is the condition of mature RRG
EWP objective(s)	8.05,3(b)
Schedule 7 targets	Condition of native water dependent vegetation
PEA/PEF criteria met	PEA 3(b) Prevents declines in native biota
BEWS QEEO	B2.2 No decline in the condition of River Red Gum and Black Box across the Basin

LTWP objective	LTWPVM5 Improve the condition of river red gum dominated EVCs
LTWP target	A positive trend in the condition score of River Red Gums dominated Ecological Vegetation Class (EVC) benchmarks at 80% of sites over the 10 year period to 2025
2020 Objective MJ1b:	By 2030, improve condition and maintain extent from baseline levels of River Red Gum (*Eucalyptus camaldulensis*) to sustain communities and processes reliant on mature River Red Gum at Bidgee Lagoons (Narrung Wetlands), Murrumbidgee Junction
2020 Targets MJ1b:	By 2030, a positive trend in the condition score of River Red Gum dominated EVC benchmarks at 80% of sites over the 10 year period OR By 2030, at stressed sites (see Wallace et al. 2020): in standardised transects that span the floodplain elevation gradient and existing spatial distribution, ≥70% of viable trees will have a Tree Condition Index Score (TCI) ≥ 10. Baseline condition of trees at Bidgee Lagoons (Narrung Wetlands), Murrumbidgee Junction to be established.

Current objective	**MJ2: 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** – (Wetland area: Bidgee Lagoons (Narrung Wetlands))
Comments	Combined/covered in MJ1b

Current objective	**MJ3: Promote a healthy and productive Lignum Shrubland (EVC 808) providing habitat for waterbird nesting and roosting** – (Wetland area: Wakool Creek)
Comments	Rationalised to align with LTWP objectives with the assumption that if condition is improved this incorporates productivity.
EWP objective(s)	8.05,3(b) 8.06,6(b)
Schedule 7 targets	Condition of priority asset - prevention of decline in native biota Diversity of native water dependent vegetation Condition of priority ecosystem functions - creation of vital habitat - habitat for prevention of decline in native species
PEA/PEF criteria met	PEA 3(b) Prevents declines in native biota PEF 1(e) Vital habitat - preventing decline of native biota
BEWS QEEO	B2.10 Maintain extent of Lignum along the Murray River from the junction with the Wakool River to downstream of Lock 3, including Chowilla and Hattah Lakes
LTWP objective	LTWPVM8: Improve the condition of shrub and lignum dominated EVCs
LTWP target	A positive trend in the condition score of Shrub and Lignum dominated EVC benchmarks at 50% of sites over the 10 year period to 2025

2020 Objective:	By 2030, improve condition and maintain extent from baseline levels of Lignum (*Duma florulenta*) to sustain communities and processes reliant on Lignum communities at Wakool Creek, Murrumbidgee Junction.
2020 Targets:	By 2030, condition in standardised transects that span the floodplain elevation gradient and existing spatial distribution, ≥70% of Lignum plants in good condition with a Lignum Condition Score (LCI) ≥4.

Current objective	**MJ4: Sustain resident populations of small-bodied native fish and opportunistic use by large-bodied native fish through maintenance of permanent pool habitat** – (Wetland area: Bidgee Lagoons (Narrung Wetlands))
Comments	MCMA deleted component related to 'opportunistic use by large-bodied native fish through maintenance of permanent pool habitat' as non-viable. Objective to focus on outcomes for small-bodied native fish.
EWP objective(s)	8.06,6(a)
Schedule 7 targets	Condition of priority asset - prevention of decline in native biota Recruitment and populations of native fish
PEA/PEF criteria met	PEA 3(b) Prevents declines in native biota PEF 1(d) Vital habitat - diversity of aquatic environments
BWS QEEO	B4.5 Improved community structure of key native fish species
LTWP objective	LTWPMV15 Maintain abundance of small-bodied native fish in wetlands
LTWP target	No negative trend in the abundance of small-bodied wetland specialist native fish in 2025
2020 Objective:	By 2030, protect and restore biodiversity by maintaining representative populations of small-bodied native fish at Bidgee Lagoons (Narrung Wetlands) Murrumbidgee Junction, including Carp Gudgeon (*Hypseleotris* spp.), Flathead Gudgeon (*Philypnodon grandiceps*) and Australian Smelt (*Retropinna semoni*).
2020 Targets:	By 2030, maintain self-sustaining populations of Carp Gudgeon (*Hypseleotris* spp.), Flathead Gudgeon (*Philypnodon grandiceps*) and Australian Smelt (*Retropinna semoni*) at Bidgee Lagoons (Narrung Wetlands), Murrumbidgee Junction. Measured as: • Adults or YoY for each species recorded in 8 out of 10 years

Current objective	**MJ5: Promote seasonal emergent and semi emergent macrophytes** — (Wetland area: Bidgee Lagoons (Narrung Wetlands))
Comments	Adopted WRIGs developed by DELWP. Some species need to be identified as currently not all aquatic WRIGs represented in the flora lists in the EWMP.
EWP objective(s)	8.05,3(b) 8.06,6(b)

Schedule 7 targets	Condition of priority asset - prevention of decline in native biota Diversity of native water dependent vegetation Condition of priority ecosystem functions - creation of vital habitat - habitat for prevention of decline in native species
PEA/PEF criteria met	PEA 3(b) Prevents declines in native biota PEF 1(e) Vital habitat - preventing decline of native biota
BEWS QEEO	None specified
LTWP objective	LTWPVM2 Improve the species richness of aquatic vegetation in wetlands
LTWP target	None specified for non-woody vegetation
2020 Objective:	By 2030, improve vital habitat at Bidgee Lagoons (Narrung Wetlands), Murrumbidgee Junction by increasing the diversity of aquatic macrophytes present across a range of Water Regime Indicators Groups.
2020 Targets:	By 2030, increase diversity of native of macrophytes at Bidgee Lagoons (Narrung Wetlands), Murrumbidgee Junction, with ≥2 species from each of the following Water Regime Indicator Groups present in 80% of years: • Aquatic (obligate submerged) (Aos) (no species recorded) • Aquatic (submerged to partially emergent) (Ase) (no species recorded) • Aquatic graminoids (persistent) (Agp) (no species recorded) • Aquatic to semi-aquatic (persistent) (Asp) (Common Blown-grass *Lachnagrostis filiformis s.l.*, Narrow-leaf Nardoo *Marsilea costulifera*, Common Nardoo *Marsilea drummondii*, Spiny Mud-grass *Pseudoraphis spinescens*) • Seasonally immersed – low growing (Slg) (Lesser Joyweed *Alternanthera denticulata s.s.*, Native Couch *Cynodon dactylon var. pulchellus*, Yellow Twin-heads *Eclipta platyglossa subsp. Platyglossa*, Common Spike-sedge *Eleocharis acuta*, Poison Pratia *Lobelia concolor*, Narrow-leaf Dock *Rumex tenax*, Tall Fireweed *Senecio runcinifolius*, Rat-tail Couch *Sporobolus mitchellii*, River Bluebell *Wahlenbergia fluminalis*) • Seasonally inundated – emergent non woody (Sen) (Warrego Summer-grass *Paspalidium jubiflorum*, Southern Cane-grass *Eragrostis infecunda*, Spiny Flat-sedge *Cyperus gymnocaulos*)

mallee
catchment management authority

Cnr Koorlong Ave & Eleventh St, Irymple