Environmental Water Management Plan

Photo: Outlet Creek
Karadoc Swamp

Karadoc Swamp

mallee
catchment management authority

Version Number	Description	Issued To	Issue Date
1.	Report structure updated following comments from EWR team	EWMP working group across CMAs and DSE	19/10/2010
2.	Report structure updated following working group discussion	EWMP working group (northern Victorian CMAs)	02/02/2011
3.	Report structure updated following working group discussion	EWMP working group (northern Victorian CMAs)	25/05/2011
4.	Working draft distributed to accompany EWMP purpose document Working draft distributed at inception meeting for Basin Plan EWMP program	EWMP working group (Statewide CMA representatives, VEWH) Basin CMAs, VEWH and scientific panel (T Hillman and J Roberts)	27/06/2012 17/12/2013
5.	Guidelines updated following feedback from 17 December meeting	Basin CMAs and scientific panel (T Hillman and J Roberts)	24/01/2014
6.	Working draft	S. Bates	12/12/2014
7.	Internal review	L. Chapman	27/02/2015
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9.	DELWP review	S. Watson	12/03/2015
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11.	Board endorsement	Mallee CMA Board Members	21/05/2015
12.	Submission of Draft to DELWP	S. Watson – DELWP	01/06/2015
13.	Updated ecological objectives – Water's Edge Consulting	D. Wood (Mallee CMA)	16/12/2020
13.	Whole EMWP review and update to align with latest DEECA Guidelines	Mallee CMA	30/06/2025

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
ANAE	Australian National Aquatic Ecosystem
ARI	Average Recurrence Interval
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
LTWMP	Long-Term Watering Plan
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
WEL	Watering Event Lessons
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). The hydrological interconnectedness and commonality of threats impacting on the waterway's values were used to group them into planning units. This EWMP has been developed for the Karadoc Swamp WMU Sub-Unit. Hereafter referred to as Karadoc Swamp in this document. The EWMP will help to guide future environmental watering activities for this area.

The target area for the Karadoc EWMP is a subunit of the Karadoc Waterway Management Unit (WMU) and is located approximately 25 km south-southeast of Mildura on the Murray River floodplain and covers 6,827 ha. This plan focuses on three wetlands, two creeks and surrounding floodplain vegetation within the WMU covering approximately 248 hectares (hereafter referred to as Karadoc) These wetlands are the target for environmental watering events and related infrastructure to contribute toward achievement of the ecological objectives for the site.

The primary use of the wetlands at Karadoc is for irrigation drainage disposal. Recently two areas became managed as Nature Conservation Reserves as recommended by the River Red Gum Forests Investigation (VEAC 2008); Lambert Island Nature Conservation Reserve and Karadoc Nature Conservation Reserve. The Mallee CMA acknowledges this will be the primary use for the site going forward and understands that any ecological and hydrological objectives recommended should complement these primary uses.

Environmental values for Karadoc include a diverse range of water dependent flora and fauna species including some listed under state, national and international treaties, conventions, Acts and initiatives. Of particular significance are the Eastern Great Egret, (*Ardea alba,* internationally listed), and Swamp Sheoak, (*Casuarina obesa,* State listed). The area also contains a number of depleted and vulnerable water dependent ecological vegetation classes and wetlands such as Lignum Swamp and Lignum Swampy Woodland. The target area has significant social values for the local community and the local indigenous community has strong connections to the area.

The long-term management goal for Karadoc is:

> *To provide a water regime which supports a seasonally connected and functional wetland complex which provide feeding and breeding habitat for small fish, frogs, waterbirds and microbats. The system should also provide refuge habitat for the endangered Murray Hardyhead and support a healthy population of Swamp Sheoak.*

To achieve this, ecological and hydrological objectives, have been designed and include two inundation stages:

- Stage A will deliver environmental water to Outlet Creek and the northern floodrunners;

  Minimum watering regime

  Provide environmental water to the target area five years in every ten from August to October to inundate fringing vegetation and maintain salinity between 5,000 EC and 30,000 EC. Allow the water level to

decrease slowly over summer to expose fringing vegetation and mud flats but retain sufficient ponding to sustain Murray Hardyhead populations.

Optimal and Maximum watering regime

Provide environmental water to the target area each year from August to October to inundate fringing vegetation and maintain salinity between 5,000 EC and 30,000 EC. Allow the water level to decrease slowly over summer to expose fringing vegetation and mud flats but retain sufficient ponding to sustain Murray Hardyhead populations.

- Stage B will deliver environmental water to Inlet Creek.

Minimum watering regime

Provide environmental water to the target area two years in every ten to a height of 37.9 m AHD. Allow ponding at this level for up to two months to freshen water in the root zone of Swamp Sheoak stands. Allow a gradual drawdown to expose the littoral zone and mudflats for wading birds, grazing waterfowl and shoreline foragers. Maintain ponding in Inlet Creek for seven months for waterbird breeding and feeding by deep water, diving and piscivorous waterbirds.

Optimal watering regime

Provide environmental water to the target area three years in every ten to a height of 37.9 m AHD. Allow ponding at this level for up to two months to freshen water in the root zone of Swamp Sheoak stands. Allow a gradual drawdown to expose the littoral zone and mudflats for wading birds, grazing waterfowl and shoreline foragers. Maintain ponding in Inlet Creek for nine months for waterbird breeding and feeding by deep water, diving and piscivorous waterbirds.

Maximum watering regime

Provide environmental water to the target area five years in every ten to a height of 37.9 m AHD. Allow ponding at this level for no more than three months to freshen water in the root zone of Swamp Sheoak stands. Allow a gradual drawdown to expose the littoral zone and mudflats for wading birds, grazing waterfowl and shoreline foragers. Maintain ponding in Inlet Creek for up to twelve months for waterbird breeding and feeding by deep water, diving and piscivorous waterbirds.

The ecological objectives for Karadoc are outlined below:

K2: By 2030, improve condition and maintain extent from baseline levels of Lignum (*Duma florulenta*), River Red Gum (*Eucalyptus camaldulensis*), and Black Box (*E. largiflorens*) and to sustain communities and processes reliant on such communities at Karadoc Swamp.

K3: By 2030, protect and restore biodiversity by maintaining representative populations of small-bodied native fish populations at the Karadoc asset, including Murray-Darling Rainbow Fish (*Melanotaenia fluviatilis*), Carp Gudgeon (*Hypseleotris* spp) and Fly-specked Hardyhead (*Craterocephalus stercusmuscarum*).

K4: By 2030, protect and restore biodiversity by maintaining representative populations of frogs at Karadoc Swamp, Karadoc.

K5a: By 2030, maintain representative populations of shallow-water and deep-water feeding guilds of waterbird (F2 and F3, respectively, after Jaensch 2002) at the Karadoc asset, by maintaining a mixture of shallow and deep-water habitats.

K5b: By 2030, maintain nesting and recruitment of non-colonial waterbirds (N1, N2, N3 and N4, after Jaensch 2002) at the Karadoc asset, by maintaining a mixture of tree, low vegetation/shrubs, and ground/islet nesting habitat.

K7: By 2030, improve condition and maintain extent from baseline (2006) levels of Black Box (*Eucalyptus largiflorens*) to sustain communities and processes reliant of such communities at the Karadoc asset.

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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 Karadoc Swamp.

The Karadoc Swamp EWMP was first developed in 2016 and ecological objectives updated in 2020. This document is a full revision of the EWMP, to update content and to align the EWMP with version 6 of the 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

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 following:

- 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 (including Melbourne Water), 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 those 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 Karadoc Swamp 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
China-Australia Migratory Bird Agreement (CAMBA)	International agreement administered under the federal *Environment Protection and Biodiversity Conservation Act 1999.*
Japan-Australia Migratory Bird Agreement (JAMBA)	
Environment Protection and Biodiversity Conservation Act (1999) (EPBC)	National
Flora and Fauna Guarantee Act (FFG)	State
Department of Energy, Environment and Climate Action advisory lists (DEECA)	State

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 international association for 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: © 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 Karadoc Swamp, 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 Karadoc Swamp. This ensures that all stakeholders and community members are aware of the Karadoc Swamp environmental watering operations.

Table 2. Stakeholder groups with an interest in environmental water at Karadoc Swamp

Stakeholder groups	Stakeholders	Needs and interest	IAP2 level	Consultation modes
Public land /water managers	Parks Victoria	Managing impacts from watering such as access, State-level environmental management	Collaborate	Monthly meetings
	Mallee CMA	N/A	N/A	N/A
	Department of Energy, Environment and Climate Action	State level environmental management planning, land manager, threatened species manager	Collaborate	Monthly meetings
River Operators	Goulburn Murray Water	Manage water storage	Collaborate	Formal meetings
Water Corporation	Lower Murray Water	Water registers and drainage management	Collaborate	Formal meetings
Local government	Mildura Rural City Council	Access during watering events	Involve	Meetings, phone calls, correspondence.
First Nations People	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
	Commonwealth Environmental Water Holder	Decision-making around annual environmental water usage.	Collaborate	Formal meetings
Private landholders	Local landholders	Managing impacts from watering such as access. Provides assistance in planning and implementation of programs.	Collaborate	Directly affected landholders will be informed of watering proposals and asked to provide feedback if relevant.
Community representatives		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 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
- Presentation at the Biodiversity-Water Catchment Partnership Committee
- In-person engagement event at local events such as markets and environmental group meetings
- Social media platforms

2.2.1 Verifying asset values

Asset values at Karadoc Swamp 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 CAM has an established working relationship with those who have an extensive knowledge of Karadoc Swamp and floodplain ecosystems. This work has been central to providing a basis for local knowledge and expertise.

Combined with the Murray Wetlands 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 considering 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

To inform the EWMP update community stakeholders were engaged in-person during local events such as the Red Cliffs Market and local community and environmental group events. This engagement included a 'Pins in Maps' activity, where the community provided information on uses and values at specific locations at the site.

This engagement supplements earlier community engagement about the Karadoc Swamp EWMP, and annual community engagement that informs the Seasonal Watering Proposal (SWP). Community consultation occurs at the IAPs level of CONSULT. Community engagement activities are summarised in Appendix 2.

2.4 TRADITIONAL OWNERS

Engagement with Traditional Owners was conducted in a 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 First People of the Millewa Mallee Aboriginal Corporation (FPMMAC) in person in October 2024. Through this engagement activity, Traditional Owner stakeholders were asked to identify the values/uses at specific sites by placing pins on a map where they occurred. Information from this consultation has informed cultural site uses and values incorporated into this EWMP. In-line with EWMP guideline, 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) and has a regional population estimated to be 67,000. Population centres include Mildura, Birchip, Sea Lake, Ouyen, Robinvale, Red Cliffs and Merbein. The boundaries of the Mallee CMA region cover almost one fifth of Victoria, making it the largest area managed by a CMA in the state.

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

The site for this plan is the Karadoc Swamp subunit of the Karadoc WMU, hereafter referred to as Karadoc Swamp. Karadoc Swamp is located in the Karadoc WMU, 15km south-east Mildura on the River Murray Floodplain (Figure 2). Wetlands identified with numbers in Figure X have been categorised according to the Victorian Wetland Environments and Extent 1994 state-wide database (Corrick and Norman 1994).

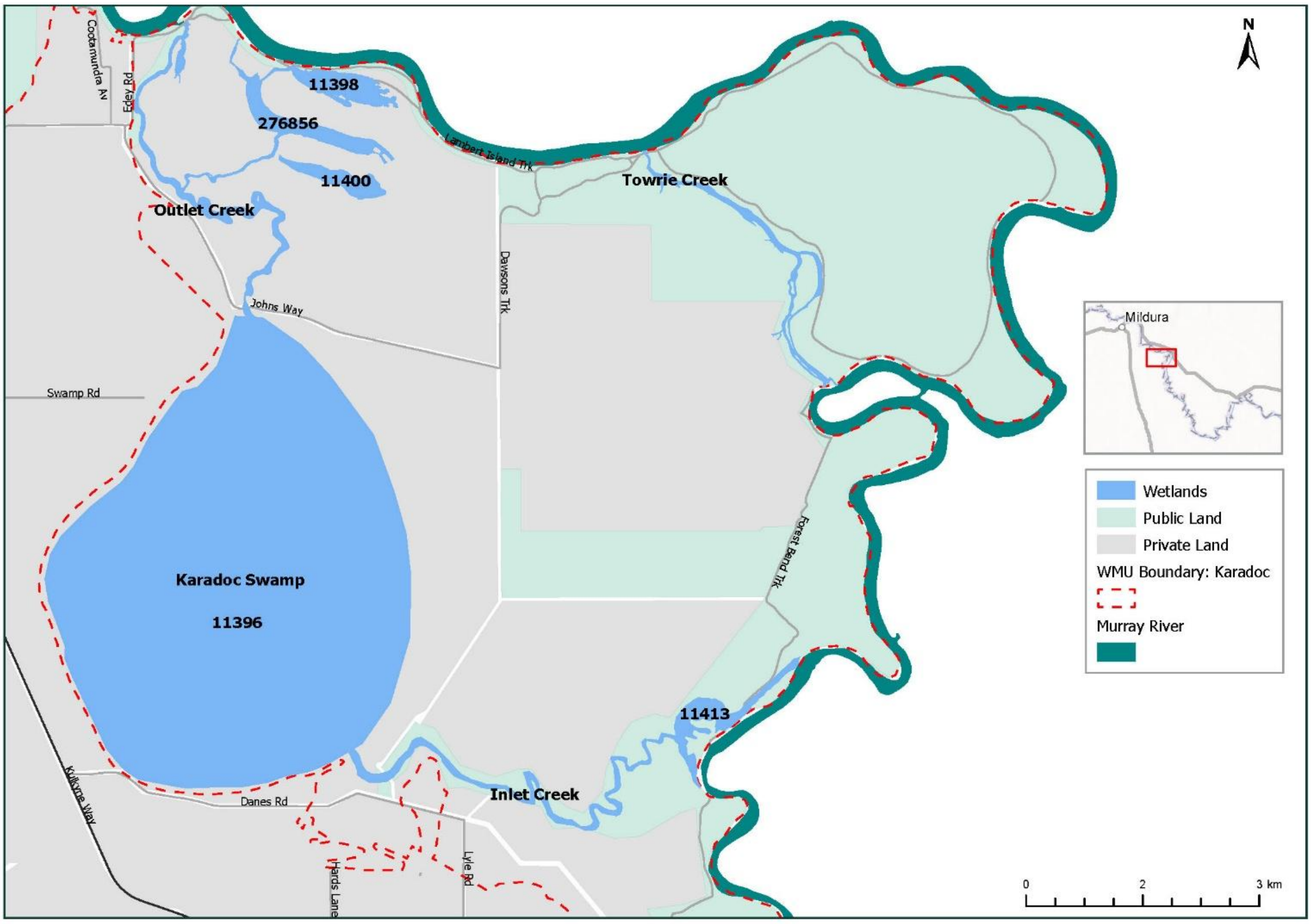

Figure 2. Karadoc Swamp wetlands overview located within the Karadoc WMU

3.1 CATCHMENT SETTING

Karadoc is situated approximately 25km south-southeast of Mildura within the Robinvale Plains Bioregion. The Robinvale Plains Bioregion is characterised by a narrow gorge confined by the cliffs along the Murray River, which is entrenched within older up-faulted Cainozoic sedimentary rocks. Alluvial deposits from the Cainozoic period gave rise to the red brown earths, cracking clays and texture contrast soils (Dermosols, Vertosols, Chromosols and Sodosols) this supports Riverine Grassy Forest and Riverine Grassy Chenopod Woodland ecosystems (DEECA, 2024).

Karadoc covers a large area and contains a series of 16 wetlands and three creeks including Karadoc Swamp, Inlet and Outlet Creeks and Towrie Creek. Situated on a broad bend in the Murray River, the apex of this bend is cut off by Towrie Creek to form Lambert Island (Ecological Associates 2007). Lambert Island is one of two Nature Conservation Reserves within Karadoc, the other being Karadoc Nature Conservation Reserve. The central floodplain, including Karadoc Swamp, is privately owned (Ecological Associates 2007). Figure X shows all wetlands within Karadoc; wetlands identified with numbers using the 1994 state-wide classification inventory as described in section X.

Karadoc Swamp is one of the largest wetlands in the Mallee Waterways Strategy with an area of 6,827.28 ha (Ecological Associates 2007) and a maximum depth of 4m (SKM 2002). Karadoc Swamp is classified as semi-permanent saline and is considered to be an area of environmental and conservation value with flora and fauna species of state, national and international significance recorded throughout (SKM 2002). The wetland has primarily been used for irrigation drainage disposal (SKM 2002) and the Swamp has suffered from significant salinization as a result of this and elevated saline water tables (Ecological Associates 2007).

Much of the Black Box and Lignum vegetation that historically surrounded the lake is now dead and has been replaced by salt tolerant halophytes (Predebon 1990). Karadoc Swamp also supports the only remaining natural stand of Swamp Sheoak, Casuarina obesa, in the Mallee region and is one of only eight known sites in Victoria (Ogyris 2007).

Surrounding land is mostly used for cropping or cleared for grazing with no buffer between Karadoc Swamp and agricultural land on its western and southern margins (SKM 2002). Inlet and Outlet Creeks, which connect Karadoc Swamp to the Murray River, support scattered vegetation (SKM 2002) and Towrie Creek supports dense macrophyte vegetation (Ecological Associates 2007).

Landsystems

The Robinvale Plains bioregion is characterised by a narrow gorge confined by the cliffs along the Murray River, which is entrenched within older up-faulted Cainozoic sedimentary rocks. Alluvium deposits from the Cainozoic period gave rise to the red brown earths, cracking clays and texture contrast soils (Dermosols, Vertosols, Chromosols and Sodosols) which supports Riverine Grassy Forest and Riverine Grassy Chenopod Woodland ecosystems (DEECA, 2024).

In order of increasing depth, the major stratigraphic units encountered within the area include the Coonambidgal Clay, Monoman Formation, Blanchetown Clay, Parilla Sands and Lower Parilla Clay.

The Coonambidgal Clay is identified by its fine silts and stiff, low plasticity clays. It acts as an aquitard (A layer of rock or sediment that prevents the flow of groundwater from one aquifer to another) at the top of the sedimentary sequence within the Murray River trench (AWE 2013a). The Coonambidgal Clay surrounding Karadoc ranges in thickness from 2 to 5m.

The Monoman Formation is identified by its grey to brown fine to coarse sands and clays and forms the floodplain aquifer (A layer of permeable rock, soil or sediment that yields water). In the floodplain the aquifer is semi-confined by the Coonambidgal Clay and variably connected to the Parilla Sands aquifer. Surrounding Karadoc Swamp it is estimated that its thickness ranges between 5 and 15m.

The Blanchetown Clay is identified by its mottled green to brown and red sandy clays. It is a lacustrine unit (relating to a lake) that acts as a regional aquitard. Data indicates that the Blanchetown Clay is present beneath Karadoc Swamp and the outer edges of the floodplain, separating the Monoman and Parilla Sands aquifers.

Thicknesses of stratigraphic units present beneath the Karadoc floodplain can be seen on Figure 3.

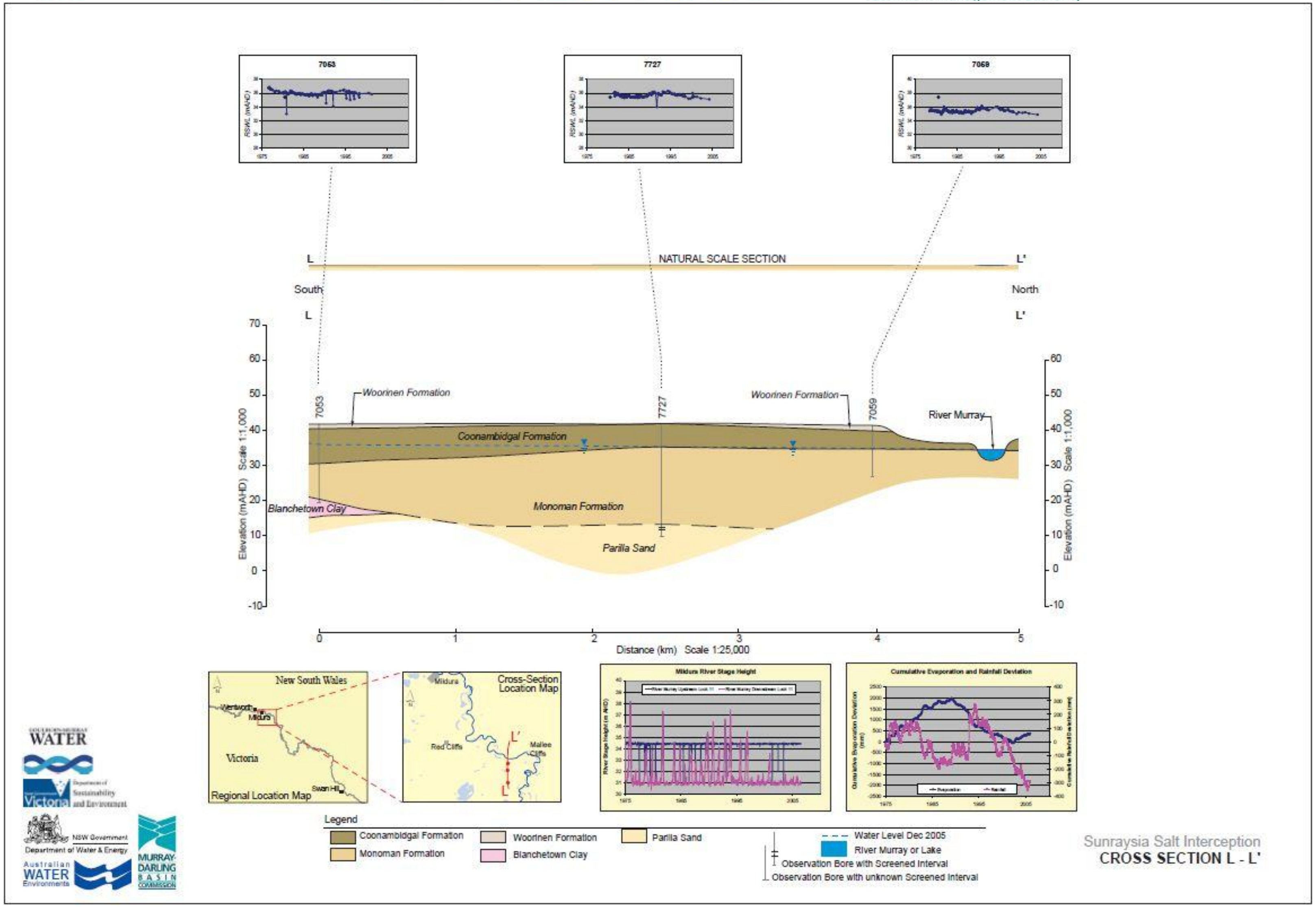

Figure 3. Lithological Cross-section – Karadoc Floodplain

3.2 LAND STATUS AND MANAGAGEMENT

The public land within the Karadoc area has historically been managed by the Department of Environment, Land, Water and Planning as State Forest in the Murray River Reserve (Parks Victoria 2012) and under the Land Conservation Council Final Recommendations (Land Conservation Council, 1989).

Karadoc Swamp contains two areas that are now managed as Nature Conservation Reserves as recommended by the River Red Gum Forests Investigation (VEAC 2008); Lambert Island Nature Conservation Reserve and Karadoc Nature Conservation Reserve. The section along the Murray River between these two reserves is managed as a part of the Murray River Park (VEAC 2008, p 63). The remainder of the target area is private land (Figure 4).

Table 3. Land and water managers at Karadoc Swamp.

Organisation	Management role
Department of Energy, Environment, and Climate Action	• State level environmental management • Administer the broader water allocation and entitlements framework and the Water Act 1989 (Vic).
Minister for Water (Victoria)	• 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), in this case, Hattah-Kulkyne National Park, where infrastructure will be operated and the wetlands, waterways and floodplain where the environmental water will be delivered. • 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.
Murray Darling Basin Authority	• Management and operation of the Murray River on behalf of the Basin States in accordance with the Water Act 2007 (Cth).
Goulburn Murray Water	• Murray River operations.
Lower Murray Water	• Murray River operations and irrigation drainage.
Mildura Rural City Council	• Local Government
Victorian Environmental Water Holder	• Manager of Victoria’s environmental water entitlements
Commonwealth Environmental Water Holder	• Manager of Commonwealth environmental water entitlements
First Nations Peoples	• Traditional Owner representation
Private Landholders	• Landholders

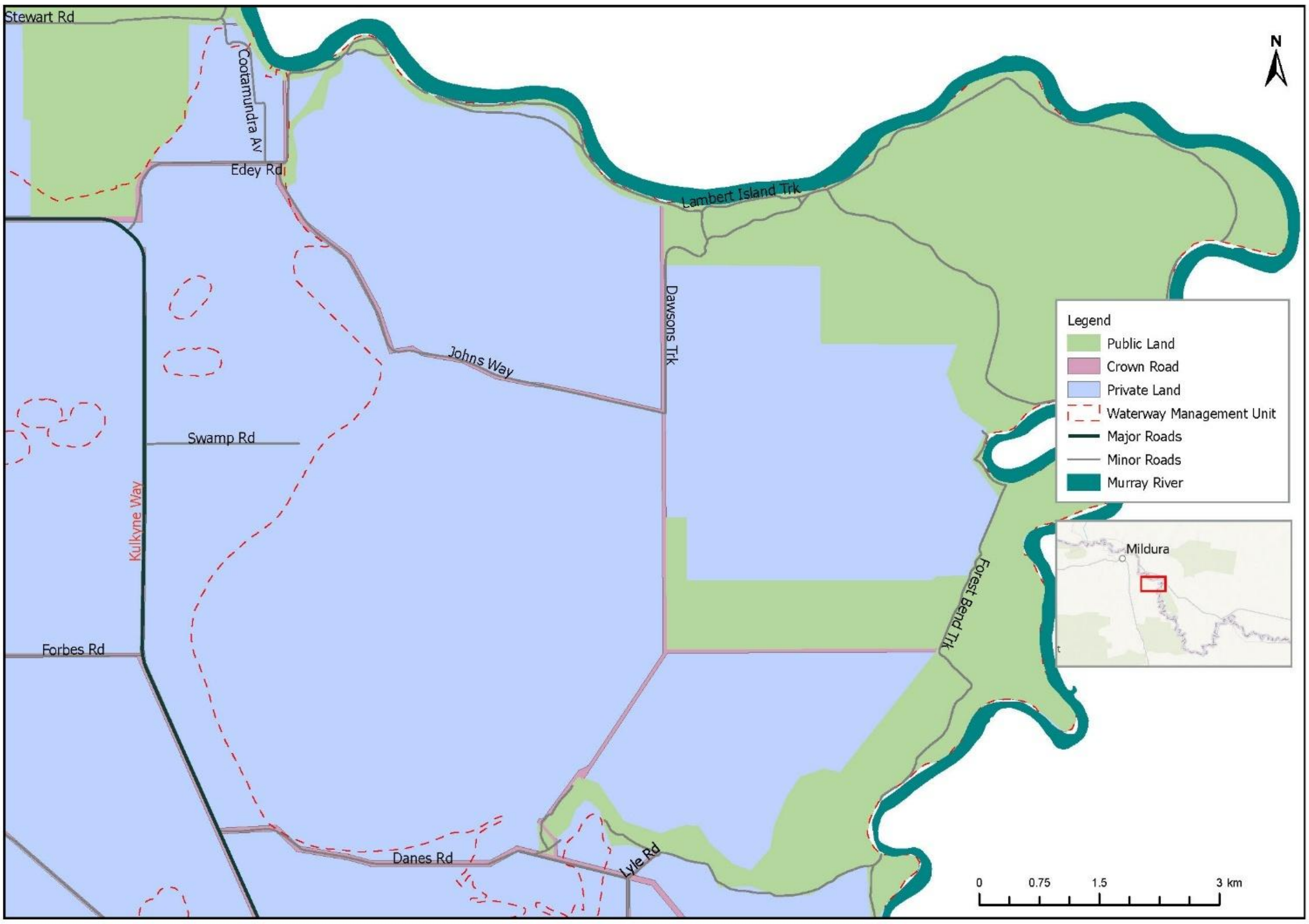

Figure 4. Land management boundaries at Karadoc Swamp

3.3 ASSET CHARACTERISTICS

The whole of Karadoc Swamp has a water requirement as a floodplain complex but the focus for this plan is restricted to a target area within Karadoc of 248 ha. Karadoc Swamp itself has been excluded from the target area as this is an active drainage disposal basin. Rehabilitation of the Swamp is not possible as long as active drainage to the lake is occurring.

Karadoc Swamp covers a series of 16 wetlands (Figure 2), six of these wetlands are included in this EWMP. 10 wetlands have been excluded as they are outside of the current target area.

The ecological and hydrological objectives in this EWMP target:

- Two un-named wetlands (#11398 and #11400), named the Northern Floodrunners for the purpose of this report;
- Inlet Creek
- Outlet Creek
- Fringing floodplain vegetation.

A brief overview of the main characteristics of the Wetlands at Karadoc Swamp is provided in Table 4.

Table 4. Wetland Characteristics at Karadoc Swamp

Characteristics	Description
Name	Karadoc Swamp Waterway Management Unit Sub-unit
Mapping ID **(Wetland Current layer)**	Northern Floodrunners, Outlet Creek and Inlet Creek
Area of wetlands in target area	Total of whole target area 6,827ha Total of all wetlands 1,917ha Total of targeted wetlands 178.55ha: • #11398 (12.60) • #11400 (16.55) • Outlet Creek including #276856 (102.67) • Inlet Creek (46.73)
Bioregion	Robinvale Plains
Conservation status	Vulnerable, Depleted and Least Concern
Land status	Regional Park, Nature Conservation Reserve, Private Land
Land manager	Parks Victoria and Private Landholders
Surrounding land use	Agriculture
Water supply	From the Murray River
Wetland category **(Wetland Current layer)**	Shallow Freshwater Marsh (northern floodrunners)
Wetland depth at capacity	Unknown

Wetland types at Karadoc Swamp are shown in Figure 5.

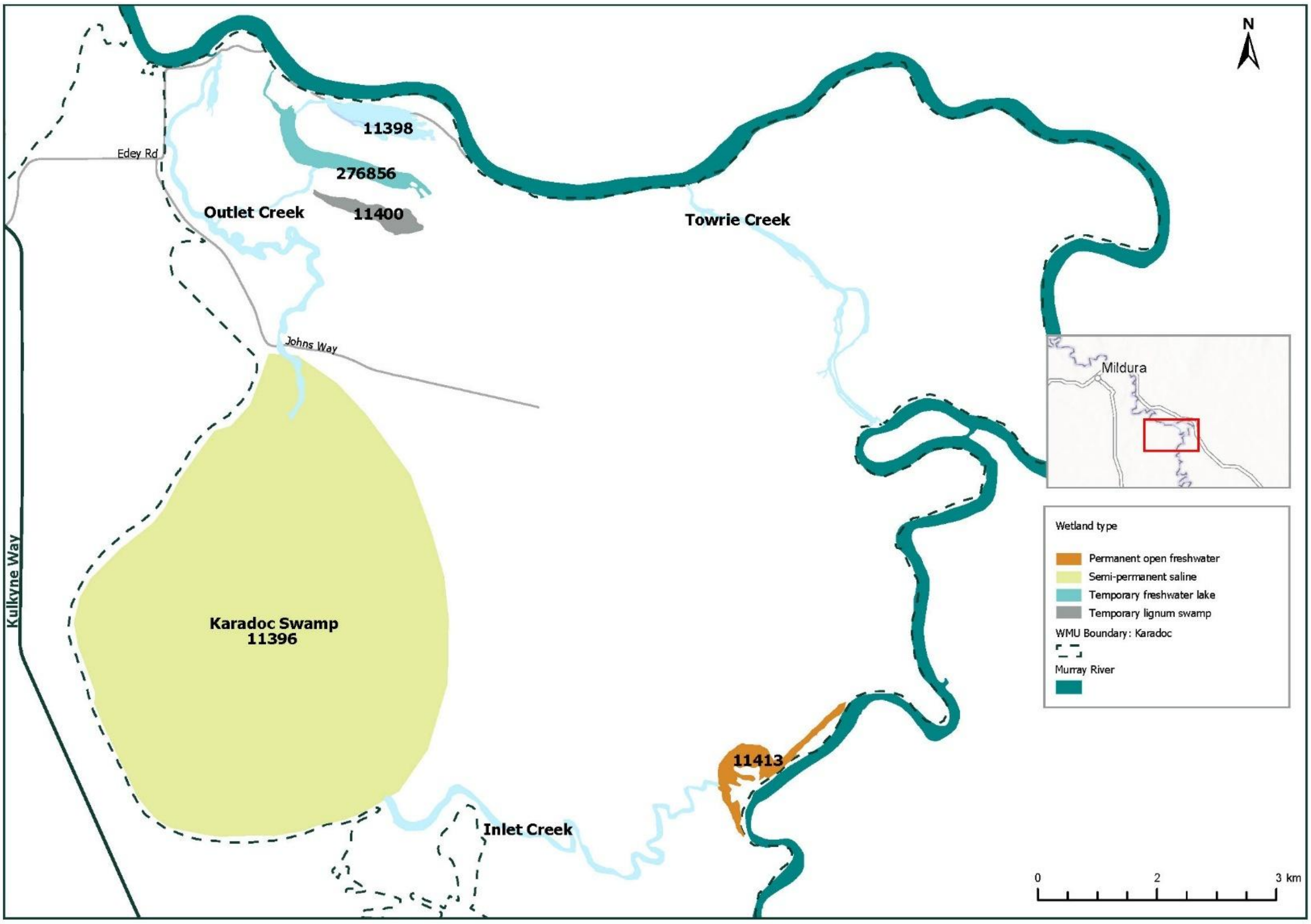

Figure 5. Wetland types (according to the Wetland Current spatial data layer)

3.3.1 Conceptualisation of the site

Conceptual models of wetlands and creeks for each of the stages of watering have been developed which describes how the ecological processes and water dependent values will interact (Figures 6 – 7). The models also provide a visual representation of some of the limiting factors and threats associated with the current conditions of the sites.

Stage A - Outlet Creek and Northern Floodrunners

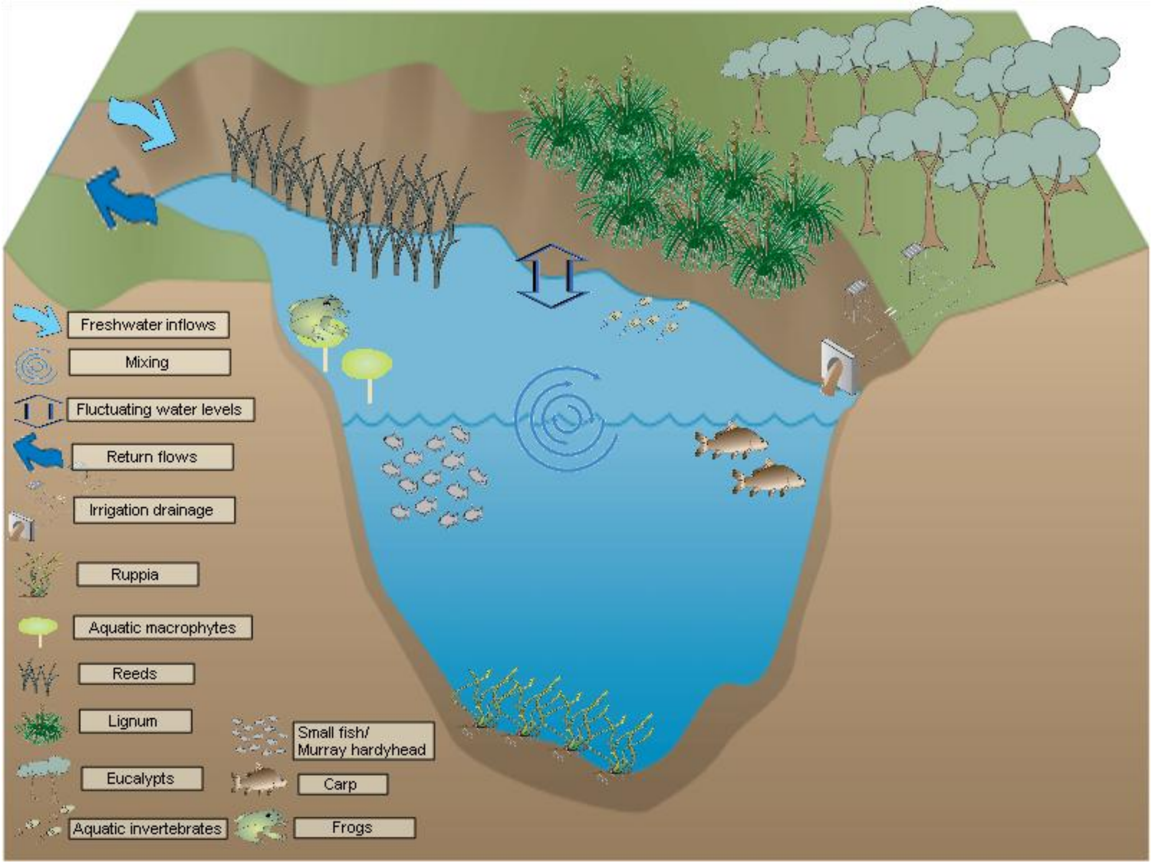

Figure 6. Conceptual model of the ecological processes, threats and values associated with Stage A

Saline **irrigation drainage** enters the wetlands, increasing salinity levels. **Freshwater inflows** to the system will be delivered as environmental water to provide **fluctuating water levels** and reduce salinity. This flooding will lead to the rapid release of nutrients from soils. The seed bank of plants and eggs of **aquatic invertebrates** emerge. This pulse in **aquatic macrophytes** and invertebrates provides food for **fish** and **frogs**. The creek and wetlands become more productive and surrounding vegetation such as **Reeds** , **Lignum** and **Eucalypt** species benefit from periodic inundation as water levels rise and fall. **Mixing** of the **freshwater inflows** and the more saline water in the wetlands and creek occurs, diluting water for **return flows** back to the River.

Stage B – Inlet Creek and adjacent floodplain

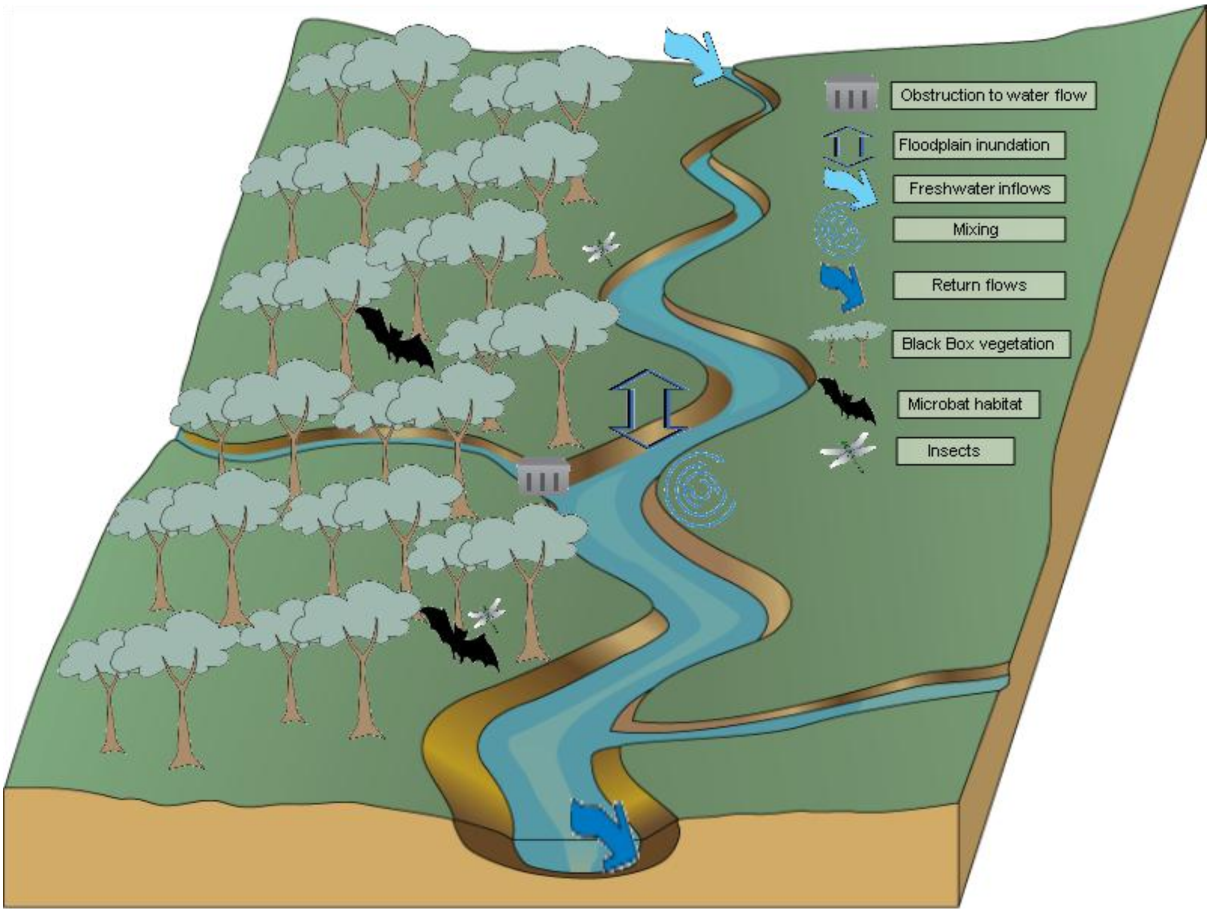

Figure 7. Conceptual model of the ecological processes, threats and values associated with Stage B

High Murray River flows which inundate the waterways and floodplain are currently reduced by **obstructions to water flow** (manmade sills etc). Environmental water could be delivered to the site to provide periodic **floodplain inundation** . This flooding leads to the rapid release of nutrients from the soils, release of the seed banks of plants and the eggs of aquatic invertebrates emerge. This pulse in biota leads to an increase in **insects** which provide an increased food source for **microbats** . The floodplain becomes more productive and the health of **Black Box vegetation** increases from periodic inundation, providing greater habitat for **microbats** . **Mixing** of the **freshwater inflows** and the more saline water in the creek occurs, diluting water for **return flows** back to the River.

3.4 ENVIRONMENTAL WATER SOURCES

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

The VEWH is responsible for holding and managing Victoria's environmental water entitlements and sourcing water from the Victorian Murray system for delivery to the target wetlands at Karadoc Swamp Wetland Complex. 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/our-watering-program/our-water-holdings.

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.

Historical hydrological regime

Prior to regulation of the Murray River the floodplain of Karadoc experienced late winter to spring flood events, of which the ecology of the floodplain has adapted to (SKM 2002). The wetlands of Karadoc were a freshwater system which flooded and returned water to the Murray River via Inlet and Outlet Creeks. Under natural conditions Karadoc Swamp received inflows from the Murray River, catchment runoff and groundwater discharge (SKM 2000). The frequency and duration of flood events under natural conditions was greater, particularly for larger (61,000ML/d) and longer lasting floods (SKM 2002).

In this part of the Murray River, the frequency, duration and magnitude of all but the largest floods have been reduced due to effects of major storages on the Murray and its tributaries (Thoms et al, 2000, p 106). The seasonal distribution of Murray River flow shows that, despite a reduction in discharge, the river retains the same annual pattern of higher flows in winter and spring with lower flows in summer and autumn (Figure 8).

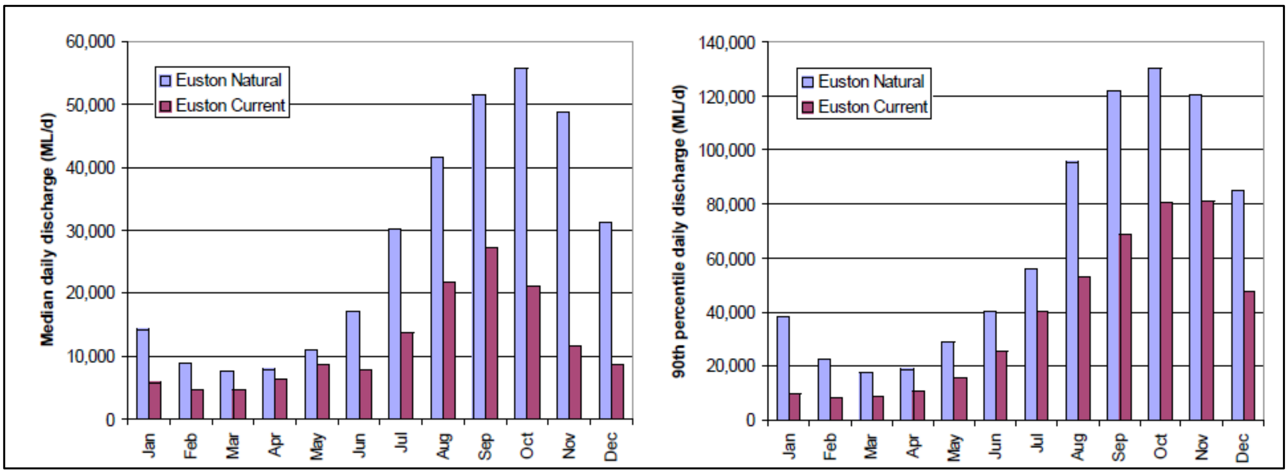

Figure 8. Distribution of median flows and 90th percentile flows for each month in the River Murray through Euston Weir for natural and current (benchmark) conditions. Data derived from MDBC MSM_Bigmod 109-year data (Ecological Associates, 2007b)

Current hydrological regime

Spells analysis undertaken (Gippel 2014) was consulted to model flow downstream of Euston. Based on the discharge thresholds presented in Figure X. Current flow thresholds of 40,000 ML/d (Outlet Creek) and 60,000 ML/d (Inlet Creek) are presented in Table 5. The thresholds from natural to baseline (post river regulation) flows show an average of approximately 50% reduction in the frequency and duration, and an average 57% increase in intervals for the baseline flows for Inlet and Outlet Creeks.

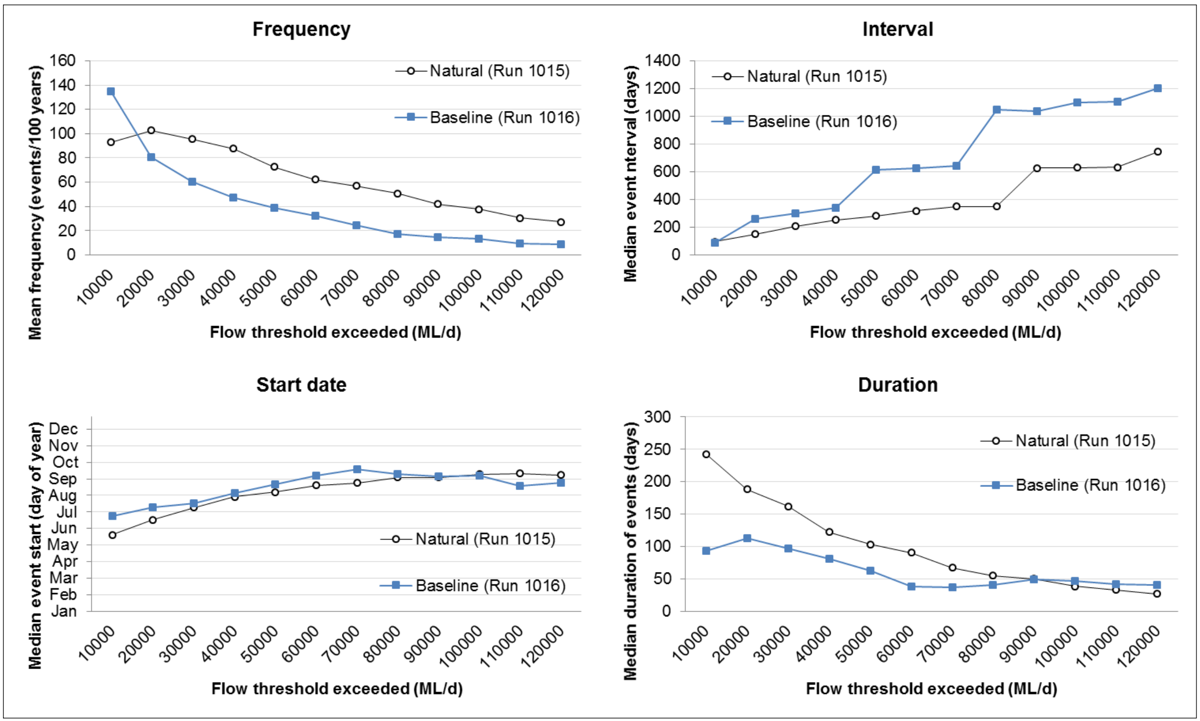

Figure 9. Comparison of Natural (pre-regulation) and Baseline Modelled Flow (post-regulation) scenarios for Euston Downstream (Gippel, 2014)

Table 5. Modelled natural and baseline flows for flow thresholds of 40,000 to 60,000 ML/d downstream of Euston

Natural (N)/ Baseline (B)	Threshold ML/d	Frequency Mean (/10yrs)	Median Interval (50% of events are less than)	Median Duration (50% of events are shorter than)	Median Event Start date	Percentage of years with Event
N	40,000	8.77	253	122	3rd Aug	87%
B	40,000	4.74	341	81	11th Aug	46%
N	50,000	7.28	283	103	13th Aug	75%
B	50,000	3.86	612	62	27th Aug	37%
N	60,000	6.23	319	91	25th Aug	63%
B	60,000	3.25	624	38	12th Sept	30%

SKM (2013) described a real-time flood at Karadoc Swamp between December 2010 to April 2011. During this flood the Swamp first filled from backflow up Outlet Creek at Murray River flows of approximately 47,000 ML/d. River flows did not run into Inlet Creek until flows reached between 50,000 and 60,000 ML/d. SKM (2013) also state that local reports suggest that even at 66,000 ML/d flow through Inlet Creek is still low due to constriction in the creek bed. Towrie Creek commences to flow at 10,000 - 15,000 ML/day with minor peaks in Murray River flows at 942.5 river km (Ecological Associates 2007). Little is documented on flow behaviour at higher river levels but it appears that water from Towrie Creek runs into an effluent that runs parallel to the Murray River and discharges at 925 river km. The sill between Towrie Creek and this effluent is 34 m AHD and the connection of the effluent to the river is at 36.5m AHD. A number of the wetlands within Karadoc are located on private land are filled via this effluent including wetland #11400.

Karadoc Swamp commences to fill at Murray River flows of 60,000 ML/d with the current infrastructure in place (Table 6). This has been modelled to occur 6.2 years per 100 years under current conditions. Under natural conditions Karadoc Swamp would have flooded at an Average Recurrence Interval (ARI) of 3.25 years per 100 years (Gippel, 2014).

Table 6. Commence to flow rate for inundation of Karadoc Swamp

Wetland	Commence to flow rate ((ML/day)
Outlet Creek and northern floodrunners	40,000 – 50,000
Inlet Creek	50,000-60,000
Towrie Creek	10,000-15,000
Karadoc Swamp	60,000

Although Euston Weir may not exactly reflect the current seasonal flow pattern for the Murray River closer to Karadoc Swamp, this is the best scientific data currently available. '*Investigations into Water Management Options for the River Murray from Robinvale to Wallpolla Island*' (Ecological Associates 2007b) states that as there are no major tributaries or losses from the River Murray in the study area (which incorporates Karadoc Swamp and surrounding wetlands) and the hydrology for this reach of the Murray River can be broadly described in terms of the flow passing Euston Weir.

4.1 GROUNDWATER AND SALINITY INTERACTIONS

Inflows

Under current conditions Karadoc Swamp receives inflows from the Channel Sands aquifer, the perched water table, irrigation drainage water, rainfall and floodwaters from the Murray River (SKM 2002). Approximately 310 ML of drainage water is discharged to Karadoc Swamp each year (SKM 2000). As the Swamp has a large, flat bed, evaporation of groundwater results in accumulation of salt in the wetland. This leads to a significant salinity impact to the river as floodwaters recede following inundation (SKM 2000). The use of the Swamp for subsurface irrigation drainage disposal since the 1970's and saline groundwater intrusion from the perched water table has also contributed to the Swamp and Creeks which connect it to the Murray River becoming salinized (SKM 2002).

Linke (1990, cited in SKM 2002) estimated groundwater discharge to Karadoc Swamp to be 325 ML/yr. The regional groundwater table is approximately 0.4 m below the surface of the centre of the wetland and generally 1 m below the surface of the lake fringe (Predebon 1990). Groundwater has been recorded between 1.15 and 2.15 m below the natural surface (Sluiter and Parsons 2000, cited in SKM 2002). Predebon (1990) states that Inlet Creek has always been an outcrop for saline groundwater. Limited surface water monitoring data for Inlet Creek is available with data collected between 2005 and 2006 returning values from 9,785 EC (brackish to saline) to in excess of 25,000 EC. (AWE, 2014)

River regulation and irrigation drainage disposal have altered the natural hydrology of the Swamp and structures on Inlet and Outlet Creek may also alter the volume of flows entering and leaving the Swamp (SKM 2002). While these Creeks are not regulated, culverts present at road crossings may cause hydraulic obstruction (SKM 2000).

4.2 ENVIRONMENTAL WATERING

Environmental water was delivered to the Karadoc Swamp Wetland Complex for the first time during 2014. This watering event involved inundation of the same area as Stage A (Outlet Creek and northern floodrunners) (Figure 9). The objectives of this watering event were to reduce the accumulated salt load from the Swamp and improve the surrounding vegetation. There was no surface water returned to the Murray River from this event and the wetlands of the target area were left to dry out naturally. A similar watering event occurred in 2024-25 where the same area was targeted. Following consecutive years of receiving natural inundation in 2022-23 and 2023-24, delivering environmental water for a third year in a row was to capitalise on watering benefits. The objectives for this watering were to maintain and improve condition of riparian and floodplain vegetation, provide habitat for native frog species and waterbirds. Monitoring from the 2024-25 environmental watering event is discussed in Section 5.

Environmental watering has previously occurred at the Karadoc Swamp Wetland Complex on numerous occasions by both natural and pumped inundation. Table 7 below outlines the watering events.

Table 7. A Summary of environmental watering at Karadoc Swamp

Water year	Waterbody	Time of inflow	Environmental Water Source	Total volume delivered (ML)	Area (ha) inundated
2010-11	Outlet Creek, Inlet Creek, Karadoc Swamp	Summer/Autumn	Natural inundation	Unknown	Unknown
2013-14	Outlet Creek	Autumn/Winter	VEWH and CEWH	400	1357.4
2016-17	Outlet Creek, Inlet Creek, Karadoc Swamp	Summer	Natural inundation	Unknown	Unknown
2022-23	Outlet Creek, Inlet Creek, Karadoc Swamp	Spring/Summer	Natural inundation	Unknown	Unknown
2023-24	Outlet Creek, Inlet Creek, Karadoc Swamp	Spring	Natural inundation	Unknown	Unknown
2024-25	Outlet Creek	Spring and Autumn	VEWH	805	TBC

Figure 9. Area of inundation for the 2024-25 watering event at Outlet Creek

5 Water Dependant Values

5.1 ENVIRONMENTAL VALUES

Wetlands and waterways on the floodplain are a vital component of the landscape which support a vast array of flora and fauna which may vary greatly with the type of 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 and creek ecosystems support distinctive communities of plants and animals and provide numerous ecosystem services to the community (DEPI 2005). Floodplain wetlands perform important functions necessary to maintain the hydrological, physical and ecological health of river systems. These ecosystem functions include:

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

Productivity, nutrient and carbon cycling

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

Wetting and drying cycles

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, which increases the diversity of the biofilms grazed by macroinvertebrates and fish.

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

Wetland filling and water recession increases the extent of the band and sedges, rushes and semi-aquatic forbs surrounding wetlands. Areas of deeper water support submerged aquatic macrophytes and promote high levels of aquatic productivity and high habitat value for frogs, fish and waterbirds.

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

5.1.2 Flora and Fauna Values

Ecological Vegetation Classes (EVCs)

Ecological Vegetation Classes (EVCs) were developed by the state of Victoria in 1994 and have been utilised since for mapping floristic biodiversity. Vegetation communities are grouped based on structural, floristic and ecological features. The Department of Environment, Energy and Climate Action (DEECA) has defined all of the EVCs within Victoria.

Within the target area, the most extensive EVCs are Lignum Swamp, Lignum Swampy Woodland and Lignum Shrubland.

For a full list of EVCs within the entire area and details on each see Appendix 3. The water dependant EVCs within the target area and their conservation status can be seen in Figure 10 and Table 8.

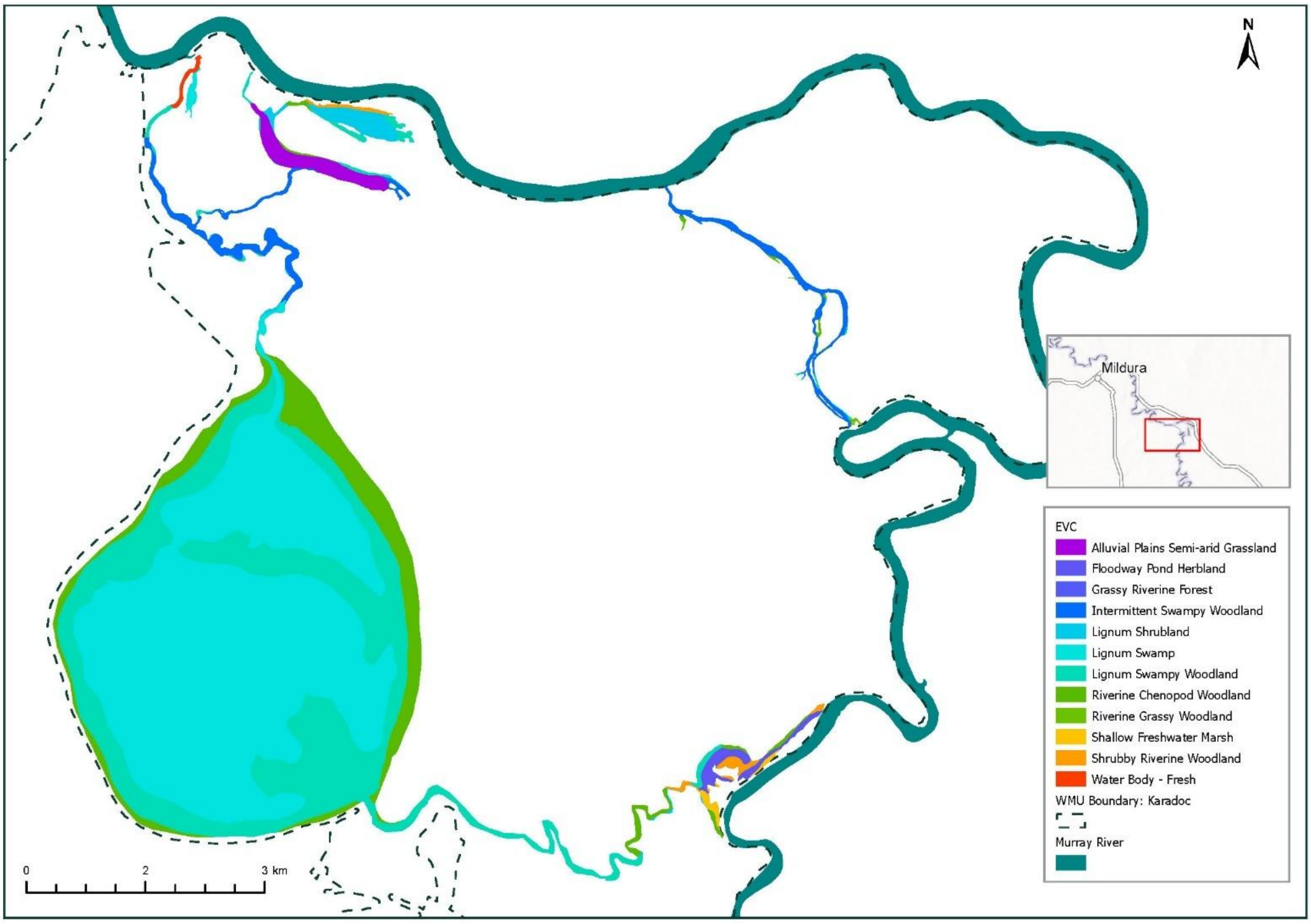

Figure 10. Water dependent EVCs within the target area of Karadoc Swamp

Table 8. Conservation status of water dependent EVCs in the target area of Karadoc Swamp

EVC no.	EVC name	Bioregional Conservation Status Robinvale Plains Bioregion	EVC Area (ha)
104	Lignum Swamp	Vulnerable	624.45
823	Lignum Swampy Woodland	Depleted	471.26
808	Lignum Shrubland	Least Concern	255.71
103	Riverine Chenopod Woodland	Depleted	128.75
810	Floodway Pond Herbland	Depleted	6.47
295	Riverine Grassy Woodland	Depleted	0.35
813	Intermittent Swampy Woodland	Depleted	67.41
818	Shrubby Riverine Woodland	Least Concern	4.91
106	Grassy Riverine Forest	Depleted	0.56
806	Alluvial Plains Semi-arid Grassland	Vulnerable	18.11

EVC no.	EVC name	Bioregional Conservation Status Robinvale Plains Bioregion	EVC Area (ha)
98	Semi-arid Chenopod Woodland	Vulnerable	0.02

Black Box, *Eucalyptus largiflorens*, is the dominant tree species in the Lignum Swampy Woodland and Riverine Chenopod Woodland EVC's which are widespread in the target area. It is also found in the Intermittent Swampy Woodland EVC that fringe Outlet Creek and Towrie Creek and the wetlands in the north. Black Box provides essential habitat and foraging opportunities for a range of species including mammals and reptiles and supports a high proportion of ground foraging and hollow-nesting species, such as microbats and the Regent Parrot. These woodlands are also an important connection to the surrounding Mallee landscape, allowing movement of fauna between these landscapes (Ecological Associates 2007a). Black Box can tolerate a range of conditions from wet to dry and saline to fresh (Roberts & Marston 2011). However, under extended periods of dry conditions trees will suffer a decline in health and eventually death (Ecological Associates 2007a).

Lignum EVC's extend across much of the target area within Karadoc and Tangled Lignum, *Muehlenbeckia florulenta*, is considered to be the most significant floodplain shrub in mainland Australia due to its extensive distribution, local dominance and value as habitat (Roberts & Marston 2011). It has particular ecological value as waterbird breeding habitat (Rogers & Ralph 2011) making it especially significant at this site. Wetland birds that breed over water, such as Egrets, use flooded Lignum shrublands (Ecological Associates 2007a) for resting and ducks, such as the Hardhead, use Lignum for nesting (Rogers & Ralph 2011).

Intermittent Swampy Woodland fringes Outlet and Towrie Creek and the wetlands in the north. This EVC is dominated by River Red Gum, Black Box, Lignum and flood stimulated understorey species (DSE 2009). River Red Gums are the most widespread eucalypt tree in Australia, occupying riparian habitats along water courses and wetlands (Roberts & Marston 2011). They provide extensive habitat for a range of fauna, and waterbirds such as the listed Intermediate Egret which use these trees for nesting. However, trees in poor condition have little contribution to the function and productivity of the ecosystem and the quality of woodland habitat is greatly reduced (Roberts & Marston 2011). River Red Gums also deposit organic woody debris to wetlands which provide structural habitat features for wetland fauna such as perching sites for waterbirds and snags for fish (Ecological Associates 2007b).

Fauna

Karadoc provides habitat for a large range of fauna. Native species recorded in the area are listed in Appendix X. This list includes a range of water dependent species which will benefit from the wetlands in the target area receiving water on a more regular basis. Of special interest and responsibility are the water dependent species listed in legislation, agreements or conventions. These are summarised in Table 9.

Table 9. Listed water dependent fauna species recorded at the Karadoc Swamp

Common name	Scientific name	Type	International agreements	EPBC Act status	FFG Act
Golden Perch	*Macquaria ambigua*	F			
Murray-Darling Rainbow fish	*Melanotaenia fluviatilis*	F			E
Pied Cormorant	*Phalacrocorax varius*	B			
Caspian Tern	*Hydroprogne caspia*	B	CAMBA, JAMBA		V
Great Knot	*Calidris tenuirostris*	B	CAMBA, JAMBA, ROKAMBA, Bonn		CE
Sanderling	*Calidris alba*	B	CAMBA, JAMBA, Bonn		
Brolga	*Grus rubicunda*	B			E
Glossy Ibis	*Plegadis falcinellus*	B	CAMBA, Bonn		
Royal Spoonbill	*Platalea regia*	B			
Intermediate Egret	*Ardea intermedia*	B			CE
Eastern Great Egret	*Ardea modesta*	B	CAMBA, JAMBA		V
Nankeen Night Heron	*Nycticorax caledonicus hillii*	B			
Australasian Shoveler	*Anas rhynchotis*	B			V
Hardhead	*Aythya australis*	B			
Blue-billed Duck	*Oxyura australis*	B			V
Musk Duck	*Biziura lobata*	B			V
White-bellied Sea-Eagle	*Haliaeetus leucogaster*	B	CAMBA		E
Regent Parrot*	*Polytelis anthopeplus monarchoides*	B			V

Lifeform type: Amphibian (A), Bird (B), Fish (F), Reptile (R)
International Agreements: China-Australia Migratory Bird Agreement (CAMBA), Japan-Australia Migratory Bird Agreement (JAMBA)
EPBC status: Conservation Dependent, Vulnerable, Endangered, Critically Endangered, Extinct in the Wild, Extinct
FFG status: Threatened, Conservation Dependent, Vulnerable, Endangered, Critically Endangered, Extinct

***Indirectly water dependent**

The species listed in Table 9 are water-dependent in that it includes species that forage or nest in or on water or require flooding to trigger breeding and fledging. The list also includes the Regent Parrot, which is indirectly dependent on water, i.e. they require riparian trees for breeding and feeding habitat. To provide breeding opportunities, habitat elements within the target area such as temporary wetlands and Black Box communities must be maintained in good condition.

Fish

A Mallee region survey of aquatic vertebrates in 2004 found four native fish species to be present in Towrie Creek. These were Carp Gudgeon, Hypseleotris spp., Fly-specked Hardyhead, Craterocephalus stercusmuscarum, Bony Bream, Nematalosa erebi, and Crimson Spotted Rainbow Fish, Melanotaenia fluviatilis (Ho et al. 2004). These species prefer slow-flowing or still waters such as billabongs and floodplain wetlands. Aquatic macrophytes and woody debris are important to small bodied native fish to provide shelter, a food source and a substrate for attachment of eggs during spawning (Rogers & Ralph 2011). The presence of small bodied native fish in floodplain wetlands and creeks is also important for waterbird diversity as they make up a large portion of the diet of many waterbird species (MDBC 2001).

Golden Perch, Macquaria ambigua, are also recorded on the species list for Karadoc.

Waterbirds

Australia's waterbirds are often nomadic and take advantage of highly variable and often temporary aquatic resources. The distribution of temporary habitat patches throughout the landscape may facilitate movement and exploitation of available resources for waterbirds (Roshier et al. 2001). The provision of environmental water to wetlands is one method of creating such habitat patches for waterbirds, allowing them to move between suitable habitat to survive and reproduce (MDBA 2009).

Forty-five species of waterbirds have been recorded within Karadoc (Appendix 4), some of which are listed in various Acts and Conventions. Waterbird diversity and abundance are influenced by wetland habitat diversity, with different species and feeding guilds using different habitats for breeding and foraging (Haig et al. 1998 cited in MDBA 2009). Water depth in particular influences waterbird diversity due to the specific feeding behaviours of different species (Bancroft et al. 2002). Managing wetlands to provide diverse habitats such as variable water depth, mud flats, inundated vegetation and areas of deep water increases the likelihood of waterbird diversity (Taft et al. 2002). The habitat use and food requirements of the waterbird guilds recorded at the site are recorded in Table 10.

Table 10. Waterbird functional groups and their resource use

Waterbird Group	Food Resource	Habitat Use	Breeding Strategy
Dabbling & Diving Ducks	Generalists; plankton, small invertebrates, plant material	Shallow Water (Dabblers), Deep Water (Divers), littoral zone	Solitary
Grazing Waterfowl (Swan, Shellduck, Wood Duck)	Plant material, seeds, invertebrates	Shallow Water, littoral zone	Colonial or solitary
Piscivores (Pelican, Cormorants)	Fish	Open and deep water	Colonial
Large Waders (Spoonbills, Ibis, Egrets, Herons)	Macroinvertebrates, fish, amphibians	Littoral zone	Colonial or solitary
Small Waders (Plovers, Dotterels)	Small invertebrates, seeds	Littoral zone, mudflats	Solitary
Shoreline Foragers (Lapwings, Hens)	Plant material, seeds, invertebrates,	Littoral zone, mudflats	Solitary or small groups

Frogs

Karadoc supports four species of native frog including Barking Marsh Frog (Limnodynastes fletcheri), Spotted Marsh Frog (Limnodynastes tasmaniensis), Plains Froglet (Crinia parinsignifera) and the Peron's Tree Frog (Litoria peroni). Like most flood dependent species frogs respond to the timing, duration and frequency of flooding, with the timing of inundation being the most significant factor. Close proximity to permanent waterbodies and drought refuges is also important for frogs. Aquatic vegetation complexity is important for many species, particularly at tadpole stage, and can drive occupancy patterns and recruitment success (Tarr & Babbitt 2002, cited in Rogers & Ralph 2011).

Frogs are considered to be good indicators of environmental health and may act as 'sentinel' species for secondary salinization (DSE 2006). A study by the Arthur

Rylah Institute (2006) found that salinity levels up to 3000 EC did not limit amphibian occupancy but amphibian diversity declined significantly between 3000 and 6000 EC. Salinity measurements taken in Inlet Creek ranged between 9,785 to in excess of 25,000 EC (AWE 2014). Studying the response of frogs to environmental water delivery to the Karadoc wetlands may give an indication of salinity levels within the wetland.

Flora

A recent search of the DEECA Advisory List of Rare or Threatened plants recorded at the Karadoc Swamp site can be found in Appendix 4. Water dependent flora species listed in the various acts and agreements which have been recorded at Karadoc Swamp are listed in Table 11.

The water dependent EVCs in which the listed species are noted as being typical are also cross referenced in Table 8 and these are mainly the EVCs which contain the River Red Gum, Black Box and Lignum communities. This gives an indication of the importance of maintaining these EVCs through an environmental water program to protect these listed species as well as the wide range of water dependent flora in the target area.

Table 11. Listed water dependent flora species recorded at Karadoc Swamp

Common name	Scientific name	FFG Act	EPBC Act Status
Spreading Emu-bush	*Eremophila divaricata subsp. divaricata*	V	
Woolly Minuria	*Minuria denticulata*	E	
Dwarf Amaranth	*Amaranthus macrocarpus var. macrocarpus*	E	
Coral Saltbush	*Atriplex papillata*	V	
Small Water-fire	*Bergia trimera*	E	
Swamp Sheoak	*Casuarina obesa*	CE	
Cane Grass	*Eragrostis australasica*	CE	
Purple Love-grass	*Eragrostis lacunaria*	E	
Bristly Love-grass	*Eragrostis setifolia*	E	
Native Peppercress	*Lepidium pseudohyssopifolium*	E	E
Tough Scurf-pea	*Cullen tenax*	E	
Yellow Tails	*Ptilotus nobilis var. nobilis*	E	
Yakka Grass	*Sporobolus caroli*	E	
Spiny-fruit Saltbush	*Atriplex spinibractea*	E	
Kneed Swainson-pea	*Swainsona reticulata*	E	
EPBC status: Conservation Dependent, Vulnerable, Endangered, Critically Endangered, Extinct in the Wild, Extinct FFG status: Threatened, Conservation Dependent, Vulnerable, Endangered, Critically Endangered, Extinct			

Swamp Sheoak, *Casuarina obesa*, is listed as threatened under the *FFG Act* and only nine extant natural populations are known in Victoria (DSE 2003). Only one of these populations occurs within the Mallee region, at Karadoc Swamp. Swamp Sheoak is generally found in low-lying swampy flats, riverbanks and along the perimeter of salt lakes (DSE 2003). Swamp Sheoak is nitrogen-fixing and has great potential in rehabilitating saline sites as it is one of the most salt tolerant native trees in Australia (Florabank 2013). The rehabilitation potential of Swamp Sheoak makes it particularly significant at Karadoc Swamp as a lowering of salt loads in the Swamp is crucial for effective ecological restoration of this site.

The site at Karadoc Swamp is found on freehold land on the western side of the wetland and is of high conservation significance (Predebon 1990). These trees are found within the Lignum Swampy Woodland EVC and have suffered significant decline over the past 20 years. Salt tolerance levels for this EVC ranges from 3,000 to 10,000EC. Elevated soil salinity as a result of reduced flooding of Karadoc Swamp is believed to be the major cause of this decline (Ogyris Ecological Research 2007). Predebon (1990) highlights the importance of this population as the only other two natural stands in Victoria are completely degraded. The watering of Outlet Creek will benefit the Swamp Sheoak on the Western side of Karadoc Swamp and also those scattered throughout the other areas of Lignum Swampy woodland EVC within the Karadoc Swamp target area.

5.1.3 Wetland depletion and rarity

Karadoc contains a series of 16 wetlands and three creeks. Two of these wetlands and two Creeks in the target area will be included in the proposed inundation event. The wetlands have been classified using the Corrick-Norman wetland classification system as Deep Freshwater Marsh and Shallow Freshwater Marsh as discussed in Section 5.1.2. Deep Freshwater Marsh is one of the most significantly altered wetland types in Victoria and the Mallee CMA Region since 1788 (Mallee CMA, Mallee Wetland Strategy, 2006, p13). Refer to Table 12 below.

It has been possible to determine the depletion of wetland types across the state using the primary category only, based on a comparison of wetland extent between the 1788 and 1994 wetland layers.

Comparison between the wetland layers has demonstrated the impact of European settlement and development on Victorian wetlands. This has been severe, with approximately one-third of the state's wetlands being lost since European settlement; many of those remaining are threatened by continuing degradation from salinity, drainage and agricultural practices (ANCA 1996).

Across the state, the greatest decreases in original wetland area have been in the freshwater meadow (43 per cent decrease), shallow freshwater marsh (60 per cent decrease) and deep freshwater marsh (70 per cent decrease) categories (DNRE 1997).

Table 12. Regional change in area of wetland type

Category	No of Wetlands in target area	Total area (ha)	Decrease in wetland area from 1788 to 1994		
			% Change in area in Victoria	% Change in area in Mallee CMA	% Change in area in Robinvale Plains
Freshwater meadow	4	14	-43	-80	-1
Shallow Freshwater Marsh	7	47	-60	-6	-4
Deep Freshwater Marsh	3	7	-70	-45	-37
Permanent Open Freshwater	1	30	-6	+5	-1
Semi-permanent Saline	1	1357	-7	+9	+100
Source: DEECA Biodiversity – NatureKit, 2024					

Victoria's wetland classification and inventory was updated in 2024 and replaces the system developed by Corrick and Norman. The updated classification is based on the Australian National Aquatic Ecosystem (ANAE) Classification Framework with data on wetlands and their classification attributes converted in GIS spatial layers.

5.2 SHARED BENEFITS

5.2.1 Traditional Owner Cultural Values

The Karadoc Swamp and surrounding wetlands is of significant cultural value to Indigenous and non-Indigenous people, with the area popular for fishing, camping, hunting and as a meeting place.

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. The high number of Indigenous Cultural Heritage sites throughout the Murray floodplain is unique in Victoria, for both concentration and diversity. They include large numbers of burial, middens and hunting sites.

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 2024) confirms that Karadoc Swamp and the River Murray are defined as areas of cultural heritage sensitivity.

Aboriginal people continue to have a connection to this country. The recorded cultural heritage sites show the area was an important meeting place for Aboriginal people, with water and food sources making it possible to survive in this landscape. Regarding Indigenous cultural values, some cultural sites have been documented through various archaeological investigations, but the true extent of the number and types of sites present is still unknown. Surveyed sites include middens, earth features, scarred trees, Aboriginal mounds and surface scatters. Surface scatters in this area may consist of chipped stone artefacts, animal bones, shell, charcoal, hearth stones, clay balls and or ochre.

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

The First Peoples of Milewa Mallee Aboriginal Corporation (FPMMAC) are the registered party for this region, which includes Karadoc Swamp. Mallee CMA work in partnership with FPMMAC through regular meetings and Talk water events with Traditional owners. FPMMAC value revegetation in wetlands with a focus on cultural significant plants as well as the importance of supporting bird breeding and wanting to see water on floodplains.

5.2.2 Recreational Values

The region is popular for swimming, camping, fishing, birdwatching, walking and boating activities along the river front. The primary purpose of the Nature Conservation Reserve's within Karadoc is conservation, although education, scientific research and passive recreation are permitted (VEAC 2008). The ability to provide many of these recreational values is highly dependent on the delivery of environmental water.

5.2.3 Economic Values

Karadoc Swamp is still used for grazing, sand extraction and irrigation drainage disposal (SKM 2002). Surrounding land is used for grazing, irrigation, stock and domestic.

5.2.4 Significance

The environmental, social and economic values outlined indicate the significance of this site. The riparian and floodplain communities of the Murray River are important to the functioning of the river system and its sustainability. The area is rich in biodiversity, essential as habitat to native species and a refuge for listed flora and fauna species.

A diverse range of flora and fauna species have been recorded in Karadoc Swamp, many of which are listed under State, Federal and International Acts and agreements. The historic waterbird records are abundant and diverse, and the site has potential to support vital foraging and breeding habitat for these birds if there was a more regular flooding regime to the wetlands and surrounding floodplain. The extensive Lignum Swamp (vulnerable) and Lignum Swampy Woodland (depleted) EVC's that dominate the target area provide essential habitat for a diverse range of fauna, particularly waterbirds. The population of FFG Act listed Swamp Sheoak at this site is the only one in the Mallee region. The importance of this population is vital as the only other remaining populations in Victoria are completely degraded (Predebon 1990). The site also has high potential to support refuge habitat for one of Victoria's most threatened species, Murray Hardyhead, and for other small native fish. The Black Box and River Red Gum woodlands that line the creeks and wetlands provide essential habitat to a range of species, including the hollow-nesting Regent Parrot and potential microbat species.

The cultural importance of Karadoc Swamp is substantial as the number of significant cultural sites in the area is high. There are also significant recreational values associated with Karadoc Swamp. These social and cultural values are important to local communities of the area. The values contained within Karadoc Swamp and specifically the target area for this plan makes this area a priority for protection and enhancement through environmental water management.

5.3 CURRENT CONDITION

Index of Wetland Condition assessments have not been undertaken for wetlands within the target area. The condition assessment described below is based on brief field observations and limited existing literature. It should be considered high priority to undertake a more up to date condition assessment.

Karadoc Swamp once supported healthy Black Box and Lignum vegetation, but the remaining trees are now severely depleted and salt-tolerant species have replaced the chenopod understorey. There are also areas of bare ground encrusted with salt (SKM 2002). Predebon (1990) found Black Box communities east of the Swamp to be in better health. SKM (2002) states that at Karadoc Swamp there is little vegetation with any value below 40m AHD.

The Swamp Sheoak population at Karadoc Swamp has declined dramatically with improved tree condition rare and localised. Trees that were still alive were found to be in poor to moderate condition. The future of this significant population of Swamp Sheoak was predicted to be alarmingly bleak in the absence of flooding and flushing of salts from the system (Ogyris 2007). Predebon (1990) highlights the importance of this population as the only other two natural stands in Victoria are completely degraded.

Towrie Creek has suffered from increased salinity levels, with Ho et al. (2004) reporting that areas of the creek had become isolated to form saline pools with salinity levels up to 8095 EC. Predebon (1990) states that Inlet and Outlet Creek have historically acted as an outcrop for saline regional groundwater and the creek beds and surrounding vegetation have declined as a result of this elevated salinity and reduced flooding frequency.

On behalf of the Mallee CMA, the Murray-Darling Freshwater Research Centre undertook a study during July 2014 to monitor vegetation and habitat for the threatened Murray Hardyhead in selected Mallee wetlands, of which Karadoc Swamp was included. Karadoc Swamp was yet to receive its environmental water entitlement so fish surveys were not required at this site. Sediment seed bank emergence was studied through obtaining sediment samples. Karadoc Swamp contained the greatest diversity of plant species from the sediment sample surveys, containing Cumbungi, Callitriche sp., Limosella sp., *Elatine gratioloides*, *Ammannia multiflora*, Transplanted Ruppia sp., & Zooplankton also emerged. The emergence of zooplankton indicates that upon inundation a viable egg bank of zooplankton could emerge and provide a food source for fish, suggesting that Karadoc Swamp could support habitat suitable for the Murray Hardyhead, provided that future water sampling returned favourable results (5,000 to 30,000 EC). Karadoc Swamp and surrounding floodplains have remained dry since July 2014.

Throughout the environmental water delivery event in 2024-25, 805 ML was delivered to Outlet Creek. Various birdlife was observed during the event as well as a positive response from aquatic plants, notably Moira grass (Figure 11).

Figure 11. Presence of Moira grass observed at Outlet Creek during 2024-25 environmental water delivery

Field surveys conducted by ARI (2025) also observed the presence of the endangered Jerry-jerry (*Ammania multiflora*) and Spreading Emu-bush (*Eremophila divaricata subsp. Divaricata*) as well as the presence of other native grasses.

Figure 12. Extensive swards of native aquatic grass *Pseudoraphis spinescens* (ARI, 2025)

5.4 CONDITION TRAJECTORY

Karadoc Swamp has received water via natural inundation in 2022-23 and 2023-22 as well as environmental water to Outlet Creek in 2024-25. Consecutive watering events have demonstrated the benefits that these sites see after receiving regular water inundation. Although recent water events have seen improvements within the wetlands, dry conditions and salinity will continue to be a threat to key species like Swamp Sheoak and Black Box. This will result in loss of valuable habitat for listed fauna within the target area and these species may be lost from the local area entirely. Wetland productivity and biodiversity, which is directly dependent on water, will continue to decline.

6 Managing Water Related Threats

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. The proposed water regime (refer Section 8) takes into account the impacts of regulation of the primary water source of the wetland (River Murray), and other activities which may impact the wetland water regimes and proposes a watering regime that will support the achievement of the environmental objectives and goals of the site.

The target areas of Karadoc Swamp have been identified in The Mallee Waterway Strategy 2014-2022 as high and medium priority reaches.

Changed water regime

The regulation of the Murray River has seen the water regime through the Karadoc section of the floodplain altered. As discussed in the hydrology section of this EWMP, the hydrology of the target areas has been greatly impacted by the regulation of the Murray River. Flow events of the magnitude required to enable flows into the creeks and wetlands of the floodplain are less frequent and of shorter duration (see section 9). This combined with dry conditions over the last decade affects the vigour of the vegetation and places trees under stress, affecting the productivity and functioning of the floodplain ecosystem.

Loss or reduction of wetland connectivity

Loss of connectivity between wetlands and the Murray River disable the biotic and abiotic connections between complex habitats. Water depth, flow and intensity define the characteristic flora and fauna, including aquatic species such as fish, shrimp, and some insects.

Introduction/increase of exotic flora and fauna

Introduced fish species Common Carp, *Cyprinus carpio*, and Mosquito fish, *Gambusia holbrooki*, pose a serious threat to the ecology of the Karadoc wetlands. Ho et al (2004) found both these species to be present during aquatic vertebrate surveys at Towrie Creek. Wetlands should be left to drawdown naturally during December and January to ensure depleted habitat for Eastern Gambusia's breeding season. Carp have been found to contribute to the loss of aquatic vegetation and increased turbidity, resulting in loss of habitat for waterfowl (Purdey & Loyn 2008). This species also competes with the native fish for habitat and food as well as having a detrimental effect on water quality (MCMA 2003).

Agricultural and other weeds are an ongoing threat and management issue along the Murray River floodplain. Colonisation by reed bed vegetation such as Cumbungi and Phragmites has occurred on the fringe of ponded water (Predebon 1990). These plants can use large amounts of water and can alter wetland character, reduce plant diversity and obstruct water flow (Roberts & Marston 2011).

Salinisation and water quality

The use of wetlands within Karadoc for irrigation drainage disposal has led to issues with salinity and resulted in degradation of the floodplain and its vegetation. Tree health has diminished and colonisation by reed bed vegetation such as Cumbungi and Phragmites has occurred on the fringe of ponded water (Predebon 1990). Salt tolerant species such as Glasswort and Saltbush sp. have succeeded where overstorey species have died out.

ASSESSING RISK

Risk assessments identify and prioritise system threats and support development of risk management strategies, that may be implemented over seasonal or decadal time frames. 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. The Mallee CMA considers consequences at the scale of their region, for the VEWH it is Victoria-wide and the CEWH it is the scale of the Murray-Darling Basin.

Not all consequences can be identified as readily and so we have provided a process that can be followed in Appendix 6.

7 Management Goals, Objectives and Targets

7.1 MANAGEMENT GOAL

Two management goals have been proposed over Karadoc focussing on both the short term (over the next one to three years) and long term (future) management.

Derived from a variety of sources such as groundwater investigations; both goals provide a watering regime which supports a natural wetland function and healthy riparian vegetation including fringing stands of Swamp Sheoak; along with providing refuge and habitat for small fish, frogs, waterbirds and microbats.

The short-term management goal is:

To provide a water regime which supports natural wetland function and healthy riparian vegetation. The wetlands should also support habitat for small-bodied fish and frogs whilst also supporting a healthy population of Swamp Sheoak.

The long-term management goal is:

To provide a water regime which supports a seasonally connected and functional wetland complex which provide feeding and breeding habitat for small-bodied fish, frogs, waterbirds and microbats. The system should also provide refuge habitat for the endangered Murray Hardyhead and support a healthy population of Swamp Sheoak.

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.

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 outlines 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) undertook a refinement process 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 Karadoc Swamp can be found in Section 5.11.1 of Butcher et al. (2020).

While every attempt has been made to make the following objectives and targets as complete as possible, there still remains gaps in critical information. As such, baselines are not able to be set at this time. In the interests of moving forward, the objectives and target 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 13. Environmental objectives and targets for Karadoc Swamp

EWMP Objective	Target
K2. By 2030, improve condition and maintain extent from baseline levels of Lignum (Duma florulenta), River Red Gum (Eucalyptus camaldulensis), and Black Box (E. largiflorens) and to sustain communities and processes reliant on such communities at Karadoc Swamp.	By 2030, condition in standardised transects that span the floodplain elevation gradient and existing spatial distribution at the Kardoc asset, ≥70% of Lignum plants in good condition with a Lignum Condition Score (LCI) ≥4. **AND** By 2030, a positive trend in the condition score of River Red Gum dominated EVC benchmarks at the Kardoc asset at 80% of sites over the 10 year period. **OR** By 2030, at stressed sites (see Wallace et al. 2020) at the Kardoc asset: 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 River Red Gum trees at needs to be established. **AND** By 2030 a positive trend in the condition score of Black Box dominated EVC benchmarks at the Kardoc asset at 80% of sites over the 10 year period **OR** By 2030, at stressed sites (see Wallace et al. 2020) at the Karadoc asset: 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 by 2030
K3: By 2030, protect and restore biodiversity by maintaining representative populations of small-bodied native fish populations at the Karadoc asset, including Murray-Darling Rainbow Fish (Melanotaenia fluviatilis), Carp Gudgeon (Hypseleotris spp) and Fly-specked Hardyhead (Craterocephalus stercusmuscarum).	By 2030, maintain self-sustaining populations Murray-Darling Rainbow Fish (*Melanotaenia fluviatilis*), Carp Gudgeon (*Hypseleotris spp*) and Fly-specked Hardyhead (*Craterocephalus stercusmuscarum)* at the Karadoc asset. Measured as: • Adults or YoY for each species recorded in 8 out of 10 years
K4: By 2030, protect and restore biodiversity by maintaining representative populations of frogs at Karadoc Swamp, Karadoc.	By 2030, vital habitat (breeding) for frogs at Karadoc Swamp, Karadoc supports the following species: Barking Marsh Frog (*Limnodynastes fletcheri*), Spotted Marsh Frog (*Limnodynastes tasmaniensis*), Plains Froglet (*Crinia parinsignifera*), and Peron's Tree Frog (*Litoria peronii*) in 80% of years.
K5a: By 2030, maintain representative populations of shallow-water and deep-water feeding guilds of waterbird (F2 and F3, respectively, after Jaensch 2002) at the Karadoc asset, by maintaining a mixture of shallow and deep-water habitats.	By 2030, 80% of representative F2 and F3 species recorded at the Karadoc asset in 8 years out of any 10-year period where conditions are suitable. • Representative F2 species include: Australasian Grebe (*Tachybaptus novaehollandiae),* Pacific Black Duck (*Anas superciliosa*), White-necked Heron (*Ardea pacifica*), Australian White Ibis (*Threskiornis molucca*), Masked Lapwing (*Vanellus miles*). • Representative F3 species include: Australian Pelican (*Pelecanus conspicillatus*), Great Cormorant (*Phalacrocorax carbo*), Little Black Cormorant (*Phalacrocorax sulcirostris*), Australian Darter (*Anhinga novaehollandiae*)

	• Feeding habitat defined as a mixture of deep feeding areas (water >1 m) and shallow feeding areas (<0.5 m depth and or drying mud) with intermittent inundation of densely vegetated shrublands.
K5b: By 2030, maintain nesting and recruitment of non-colonial waterbirds (N1, N2, N3 and N4, after Jaensch 2002) at the Karadoc asset, by maintaining a mixture of tree, low vegetation/shrubs, and ground/islet nesting habitat.	There is a lack of data on species that breed at the site. The expectation is that the list of species commonly nesting at the Karadoc asset will be confirmed over time. By 2030, at least two of the following species to be recorded as nesting and/or breeding at the Karadoc asset in 7 out of any 10-year period in which nesting/breeding conditions are suitable: • Representative N1 and N2 species include: White-bellied Sea Eagle (*Haliaeetus leucogaster*), • Representative N3 and N4 species include: Australasian Grebe (*Tachybaptus novaehollandiae*), Masked Lapwing (*Vanellus miles),* Pacific Black Duck (*Anas supercilliosa*)
K7: By 2030, improve condition and maintain extent from baseline (2006) levels of Black Box (Eucalyptus largiflorens) to sustain communities and processes reliant of such communities at the Karadoc asset	A positive trend in the condition score of Black Box dominated EVC benchmarks at the Karadoc asset at 50% of sites over the 10 year period. **OR** By 2030, at stressed sites (see Wallace et al. 2020) at the Karadoc asset: 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 Black Box trees needs to be established to ensure TCI good is achievable - may need to rewrite target and adaptively manage this as condition improves.

7.3 REGIONAL SIGNIFICANCE

As shown above in Section 5.1, Karadoc Swamp supports a range of environmental values with local, regional and Murray-Darling Basin significance. These values inform the above environmental objectives. Details of links between the environmental objectives and environmental outcomes at a regional and basin scale are provide in Appendix 6.

The management goals and environmental objectives and targets are aligned with the regional goals of the Mallee Waterway Strategy 2014-2022 as described in Section 7.1. The Mallee Water Strategy 2014-2022 identifies Karadoc Swamp as high and medium priority wetland in the Karadoc WMU.

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 Plan's (LTWP), the Basin-wide Environmental Watering Strategy (BWS) and annual Basin environmental watering priorities.

Details on the alignment of the updated Karadoc Swamp EWMP environmental objectives to the Basin Plan are provided in Table 14. The mapping of objectives to Schedule 7 targets, the BWS and LTWP are provided by Butcher et al., 2020 in Appendix 7. As well as alignment with Basin Plan, the objectives have alignment with Basin-wide environmental Watering Strategy objectives and State level Long-term Watering Plan objectives.

Table 14. Mapping of environmental objectives to the Basin Plan

EWMP Objective	Alignment with Basin Plan		
	8.05 Ecosystem and biodiversity	**8.06** Ecosystem function	**8.07** Ecosystem resilience
K2. By 2030, improve condition and maintain extent from baseline levels of Lignum (Duma florulenta), River Red Gum (Eucalyptus camaldulensis), and Black Box (E. largiflorens) and to sustain communities and processes reliant on such communities at Karadoc Swamp.	8.05, 3(b)	n/a	n/a
K3: By 2030, protect and restore biodiversity by maintaining representative populations of small-bodied native fish populations at the Karadoc asset, including Murray-Darling Rainbow Fish (Melanotaenia fluviatilis), Carp Gudgeon (Hypseleotris spp) and Fly-specked Hardyhead (Craterocephalus stercusmuscarum).	n/a	8.06, 6(b)	n/a
K4: By 2030, protect and restore biodiversity by maintaining representative populations of frogs at Karadoc Swamp, Karadoc.	8.05, 3(b)	8.06, 6(b)	n/a
K5a: By 2030, maintain representative populations of shallow-water and deep-water feeding guilds of waterbird (F2 and F3, respectively, after Jaensch 2002) at the Karadoc asset, by maintaining a mixture of shallow and deep-water habitats.	8.05, 3(b)	n/a	n/a
K5b: By 2030, maintain nesting and recruitment of non-colonial waterbirds (N1, N2, N3 and N4, after Jaensch 2002) at the Karadoc asset, by maintaining a mixture of tree, low vegetation/shrubs, and ground/islet nesting habitat.	8.05, 3(b)	8.06, 6(b)	n/a
K7: By 2030, improve condition and maintain extent from baseline (2006) levels of Black Box (Eucalyptus largiflorens) to sustain communities and processes reliant of such communities at the Karadoc asset	8.05, 3(b)	n/a	n/a

8 Environmental Water Requirements and Intended Water Regime

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

The optimal, minimum and maximum watering regimes are 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.

8.1 WATERING REQUIREMENTS AND INTENDED WATERING REGIMES

Hydrological objectives describe the components of the water regime required to achieve the ecological objectives at this site. The hydrological requirements to achieve each of these objectives are presented in Table 15.

Black Box woodlands require flooding to occur every three to seven years with durations of two to six months. This species can tolerate shorter flood durations, but plant vigour will suffer. Although timing of flood events is not crucial for Black Box it will affect understorey and other woodland biota. Black Box trees may survive prolonged periods of 12 to 16 years with no flooding, but tree health will suffer, and woodland will become dysfunctional (Roberts and Marston, 2000).

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

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

Flooding of wetland and floodplain vegetation in spring and summer provides a source of food, refuge and nesting sites and materials for waterbirds (Kingsford and Norman, 2002). Food availability is enhanced in wetlands that have been subjected to dry periods of one or more years prior to filling (Briggs, Lawler and Thornton, 1997). Receding waters levels over summer provide shallow open water and mudflats which are important foraging habitat for wading birds (Ecological Associates, 2013).

Hydrological objectives are designed through knowledge and understanding of the hydrology of the area and describe the components of the water regime required to achieve the ecological objectives at this site. Please see Table 15 for hydrological objectives at Karadoc Swamp.

Table 15. Hydrological objectives for Karadoc Swamp

Environmental Objective	Water management area	Hydrological Objectives											
		Mean frequency of events (Number per 10 years)			Tolerable interval between events (years)		Duration of Ponding (months)			Preferred timing of inflows	Target supply level (m) AHD	Volume to fill to TSL (ML)	Volume to maintain at TSL (ML)
		Min	Opt	Max	Min	Max	Min	Opt	Max				
K3: By 2030, protect and restore biodiversity by maintaining representative populations of small-bodied native fish populations at the Karadoc asset, including Murray-Darling Rainbow Fish (Melanotaenia fluviatilis), Carp Gudgeon (Hypseleotris spp) and Fly-specked Hardyhead (Craterocephalus stercusmuscarum).	Northern Floodrunners & Outlet Creek	5	1	1	1	2	Permanent ponding with top-ups to freshen			Late winter/early spring	36.1		36.1
K3: By 2030, protect and restore biodiversity by maintaining representative populations of small-bodied native fish populations at the Karadoc asset, including Murray-Darling Rainbow Fish (Melanotaenia fluviatilis), Carp Gudgeon (Hypseleotris spp) and Fly-specked Hardyhead (Craterocephalus stercusmuscarum).	Inlet Creek	5	1	1	1	2	Permanent ponding with top-ups to freshen			Late winter/early spring	37.9		37.9
K5a: By 2030, maintain representative populations of shallow-water and deep-water feeding guilds of waterbird (F2 and F3, respectively, after Jaensch 2002) at the Karadoc asset, by maintaining a mixture of shallow and deep-water habitats.	Outlet Creek	Variability in water level					Permanent ponding with variable water level to alternately inundate/expose fringing vegetation and mud flats			Late winter/early spring	36.1		36.1
K5b: By 2030, maintain nesting and recruitment of non-colonial waterbirds (N1, N2, N3 and N4, after Jaensch 2002) at the Karadoc asset, by maintaining a mixture of tree, low vegetation/shrubs, and ground/islet nesting habitat.	Inlet Creek	Variability in water level					Permanent ponding with variable water level to alternately inundate/expose fringing vegetation and mud flats			Late winter/early spring	37.9		37.9

Environmental Objective	Water management area	Hydrological Objectives											
		Mean frequency of events (Number per 10 years)			Tolerable interval between events (years)		Duration of Ponding (months)			Preferred timing of inflows	Target supply level (m) AHD	Volume to fill to TSL (ML)	Volume to maintain at TSL (ML)
		Min	Opt	Max	Min	Max	Min	Opt	Max				
K2. By 2030, improve condition and maintain extent from baseline levels of Lignum (Duma florulenta), River Red Gum (Eucalyptus camaldulensis), and Black Box (E. largiflorens) and to sustain communities and processes reliant on such communities at Karadoc Swamp.	Northern Floodrunners & Outlet Creek	2	3	5	2	15	7	9	12	Late winter/early spring	36.1		36.1
Provide vegetation health and structure in the fringing Lignum, Black Box and River Red Gum woodlands	Inlet Creek	2	3	5	2	15	7	9	12	Late winter/early spring	37.9		37.9
K4: By 2030, protect and restore biodiversity by maintaining representative populations of frogs at Karadoc Swamp, Karadoc.	Northern Floodrunners & Outlet Creek	5	1	1	1	1	Permanent ponding with top-ups to freshen			Late winter/early spring	36.1		36.1
K4: By 2030, protect and restore biodiversity by maintaining representative populations of frogs at Karadoc Swamp, Karadoc.	Inlet Creek	5	1	1	1	1	Permanent ponding with top-ups to freshen			Late winter/early spring	37.9		37.9

Stage A

Minimum watering regime

Provide environmental water to the target area five years in every ten from August to October to inundate fringing vegetation and maintain salinity between 5,000 EC and 30,000 EC. Allow the water level to decrease slowly over summer to expose fringing vegetation and mud flats but retain sufficient ponding to sustain Murray Hardyhead populations.

Optimal and Maximum watering regime

Provide environmental water to the target area each year from August to October to inundate fringing vegetation and maintain salinity between 5,000 EC and 30,000 EC. Allow the water level to decrease slowly over summer to expose fringing vegetation and mud flats but retain sufficient ponding to sustain Murray Hardyhead populations.

Stage A involves the delivery of approximately 850 ML of environmental water to Outlet Creek and selected surrounding northern floodrunners to a height of 36.1 m AHD to inundate an area of 180 ha (Figure 13). Timing of this is proposed between August and November with possible top-ups in April to June. This stage requires substantial works as four earthen levees are required to contain water withing the target area. This is the stage that will be employed in the early phases of water delivery to Karadoc, and will ensure inundation of Outlet Creek, Northern floodrunners and connectivity with the northern end of Karadoc Swamp and will be left to drawdown naturally.

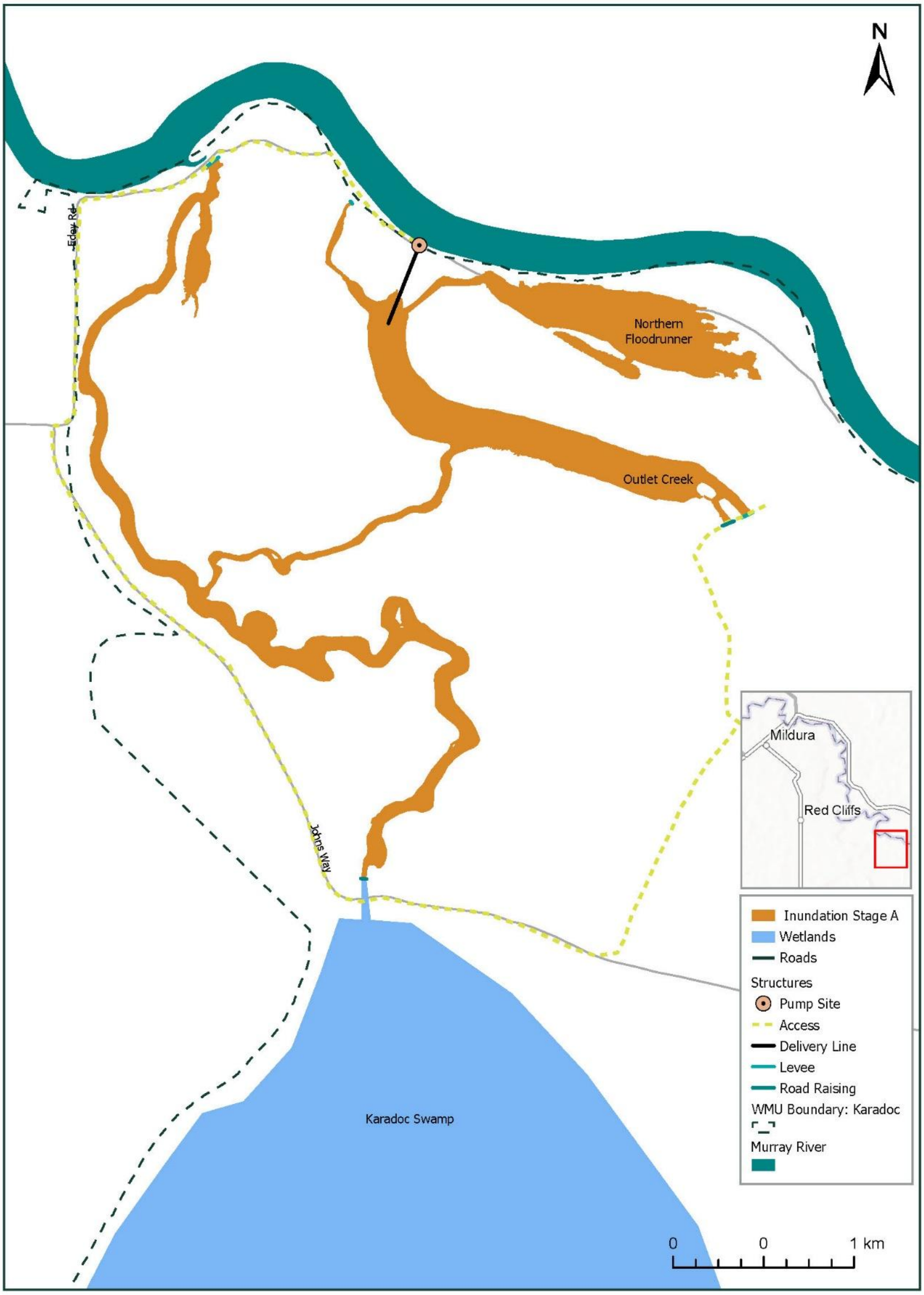

Figure 13. Inundation extent under stage A

Stage B

Minimum watering regime

Provide environmental water to the target area two years in every ten to a height of 37.9 m AHD. Allow ponding at this level for up to two months to freshen water in the root zone of Swamp Sheoak stands. Allow a gradual drawdown to expose the littoral zone and mudflats for wading birds, grazing waterfowl and shoreline foragers. Maintain ponding in Inlet Creek for seven months for waterbird breeding and feeding by deep water, diving and piscivorous waterbirds.

Optimal watering regime

Provide environmental water to the target area three years in every ten to a height of 37.9 m AHD. Allow ponding at this level for up to two months to freshen water in the root zone of Swamp Sheoak stands. Allow a gradual drawdown to expose the littoral zone and mudflats for wading birds, grazing waterfowl and shoreline foragers. Maintain ponding in Inlet Creek for nine months for waterbird breeding and feeding by deep water, diving and piscivorous waterbirds.

Maximum watering regime

Provide environmental water to the target area five years in every ten to a height of 37.9 m AHD. Allow ponding at this level for no more than three months to freshen water in the root zone of Swamp Sheoak stands. Allow a gradual drawdown to expose the littoral zone and mudflats for wading birds, grazing waterfowl and shoreline foragers. Maintain ponding in Inlet Creek for up to twelve months for waterbird breeding and feeding by deep water, diving and piscivorous waterbirds.

Under Stage B, 569.7ML of environmental water will be delivered to Inlet Creek to a height of 37.9m AHD to inundate a total area of 68 hectares, during August to November or April to June. Ponding will be maintained for up to twelve months. (Figure 14).

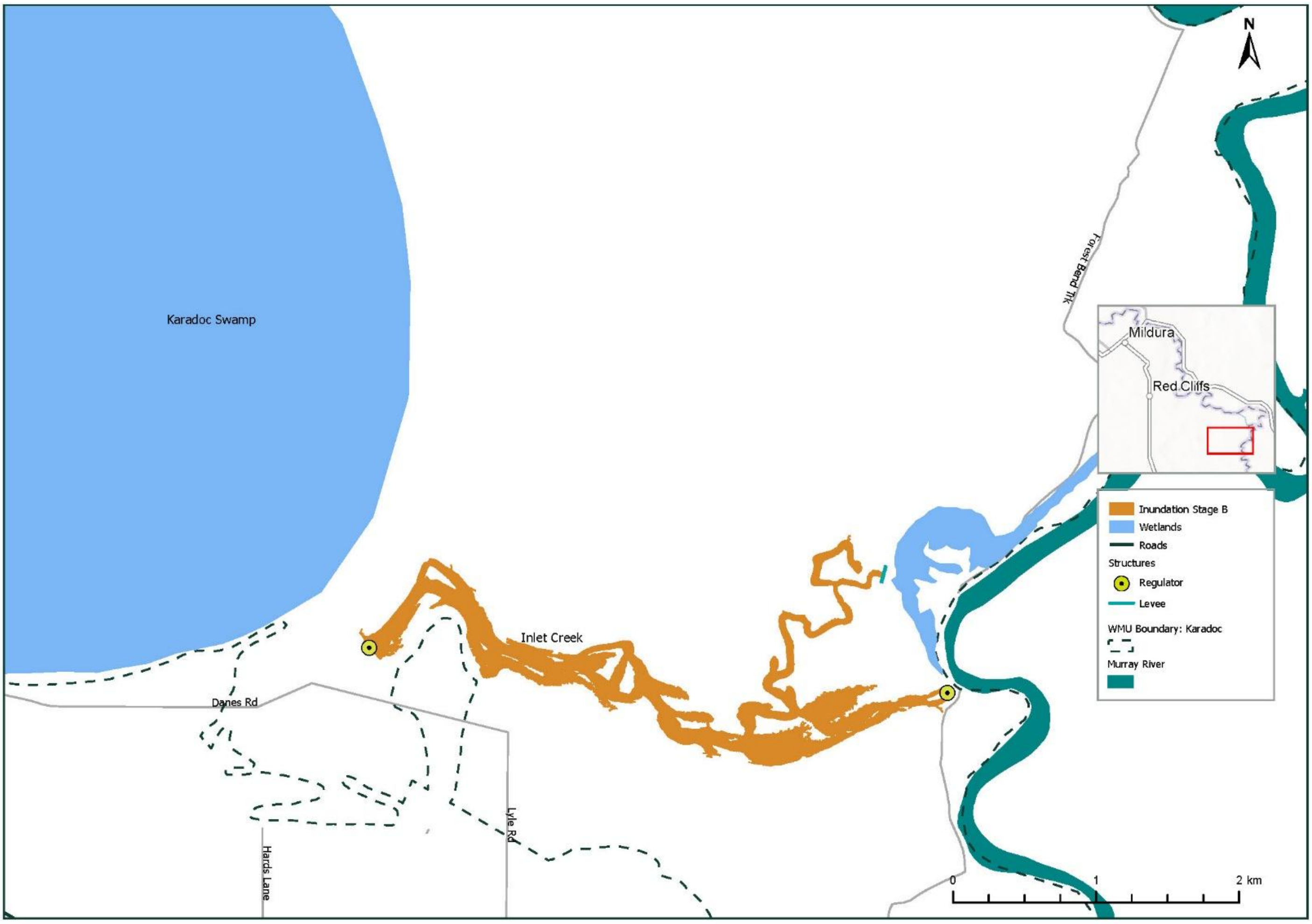

Figure 14. Inundation extent under Stage B

8.2 EXPECTED WATERING EFFECTS

This section aims to explicitly outline potential watering actions to achieve the stated environmental objective and expected watering effects.

Table 16. Expected watering effects and potential watering action required to achieve environmental objectives

Objective code	Environmental Objective	Potential Watering Action	Expected Watering Effect
K2	**K2.** By 2030, improve condition and maintain extent from baseline levels of Lignum (Duma florulenta), River Red Gum (Eucalyptus camaldulensis), and Black Box (E. largiflorens) and to sustain communities and processes reliant on such communities at Karadoc Swamp.	Facilitate flooding to 36.1 m AHD every 3 in 10 years during late winter/early spring, with ponding for 9 months.	Maintain appropriate seasonal variation in water levels to improve condition and extent of River Red Gum and Black Box and related communities and processes.
K3	**K3:** By 2030, protect and restore biodiversity by maintaining representative	Achieved through watering actions for other objectives.	Inundate areas of exposed sediments to increase zooplankton abundance

	populations of small-bodied native fish populations at the Karadoc asset, including Murray-Darling Rainbow Fish (Melanotaenia fluviatilis), Carp Gudgeon (Hypseleotris spp) and Fly-specked Hardyhead (Craterocephalus stercusmuscarum).		and available vegetation to coincide with breeding.
K4	**K4:** By 2030, protect and restore biodiversity by maintaining representative populations of frogs at Karadoc Swamp, Karadoc.	Facilitate flooding to 36.1 (for northern floodrunners & Outlet Creek) and 37.9 (for Inlet Creek) m AHD every year during late winter/early spring. Permanent pondings are optimal, requiring top-ups to freshen.	Appropriate seasonal variation in water levels provides suitable habitat and food resources for frogs.
K5a	**K5a:** By 2030, maintain representative populations of shallow-water and deep-water feeding guilds of waterbird (F2 and F3, respectively, after Jaensch 2002) at the Karadoc asset, by maintaining a mixture of shallow and deep-water habitats.	Achieved through watering actions for other objectives.	Suitable habitat (food refuge) is provided in flood wetland vegetation in spring and summer.
K5b	**K5b**: By 2030, maintain nesting and recruitment of non-colonial waterbirds (N1, N2, N3 and N4, after Jaensch 2002) at the Karadoc asset, by maintaining a mixture of tree, low vegetation/shrubs, and ground/islet nesting habitat.	Achieved through watering actions for other objectives.	Suitable habitat (food refuge) is provided in flood wetland vegetation in spring and summer.
K7	**K7:** By 2030, improve condition and maintain extent from baseline (2006) levels of Black Box (Eucalyptus largiflorens) to sustain communities and processes reliant of such communities at the Karadoc asset	Achieved through watering actions for other objectives.	Condition and extent of black box is improved/maintained from baseline 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 (refer to Table 15). The planning scenarios under different seasonal conditions for Karadoc Swamp are described in Figure 15. The example watering actions presented in Figure 15 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.

Planning scenario	Drought	Dry	Average	Very wet
Expected Conditions	Limited water, drying likely over summer	Limited water available to manage risks	Unregulated flows and storage releases enable facilitated watering	Large unregulated flows, releases from storage and piggy-back events
	Protect	Maintain	Recover	Enhance
Management Objectives	•Avoid critical loss •Maintain refuges •Avoid catastrophic events	•Maintain wetland function •Manage within species tolerance	•Improve ecological health and resilience •Improve recruitment opportunitie s	•Facilitate dispersal •Support recruitment
Example watering actions	•Provide low volumes to protect priority environment -al assets •Maintain refuges (permanent habitat pool in deepest part of freshwater marsh)	•Provide environment al water in spring to maintain aquatic vegetation and littoral zone, and support sedentary waterbird species •Manage risks such as invasive species	•Inundate exposed sediments in spring to increase aquatic macrophyte extent •Inundate Black Box communities •Maintain suitable water levels to support shallow feeding waterbirds •Provide nesting habitat for N3 and N4 waterbirds	•Top up natural flows as needed to meet target water levels •Manage inundation to avoid exceeding maximum ponding durations •Inundate trees, low vegetation/ shrubs and ground/islet habitat to support and recruit N1, N2, N3 and N4 waterbirds •Provide deep water habits for deep-feeding waterbirds

Figure 15. Indicative seasonally adaptive approach

9 Environmental Water Delivery Infrastructure

9.1 WATER DELIVERY INFRASTRUCTURE

No current infrastructure. Temporary works are required to facilitate environmental water delivery.

9.2 CONSTRAINTS

The existing arrangements limit the extent of floodplain which can be inundated by environmental watering in Karadoc. Currently water begins to break out through low points and return to the Murray River rather than being held on the floodplain at higher levels. Infrastructure such as permanent levees and regulators would increase the extent of inundation to the whole target area and prevent this breakout.

10 Demonstrating Outcomes

10.1 ENVIRONMETNAL MONITORING

The following monitoring activities have been proposed for the Karadoc Swamp target area (Table 17). 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. The link between stated objectives and monitoring priorities are described in Table 17.

Table 17. Environmental monitoring at Karadoc Swamp 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
K2	Condition and extend of lignum	What is the baseline extent? Has the extent changed with environmental watering? Has the condition improved with environmental watering? By 2030, are >70% of lignum plants in good conditions, with a lignum score of >4?	Undertake Lignum population monitoring using standardised transects that span the floodplain elevation gradient and existing spatial distribution	Every three years
K2	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
K3	Abundance and diversity of populations of small bodied native fish	Are self-sustaining populations of small-bodied fish (gudgeon spp. And Murray-Darling rainbow fish) present at Karadoc Swamp (with young-of-year recorded in 8 of 10 years)?	Undertake fish surveys targeting small-bodied native fish.	Annually
K4	Abundance and diversity of populations of frogs	Are self-sustaining populations of frogs present at Karadoc Swamp?	Undertake frog surveys (audio recordings and/or presence of tadpoles).	Annually
K5a	Abundance and diversity of populations of shallow-water and deep-water feeding guilds of waterbirds. Condition and extent of shallow and deep-water habitats	Is the condition or extent of shallow and deep-water habitats improving with environmental watering? Are 80% of representative shallow-water and deep-water feeding waterbirds recorded at Karadoc Swamp in 8 of any 10-year period where conditions are suitable?	Undertake waterbird surveys.	Intervention monitoring at an appropriate time after watering.
K5b	Nesting and recruitment of non-colonial waterbirds	Are at least two of the representative waterbird species recorded as nesting and/or breeding at Karadoc Swamp in 7 of any 10-year period in which conditions are suitable?	Undertake waterbird surveys.	Intervention monitoring at an appropriate time after watering.

Objective	Monitoring Focus	Monitoring Question	Method	When
K7	Condition and extent of black box	Is the condition of black box improving? What is the extent of black box 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.	Suitable time after delivery

10.2 MONITORING PRIORITYIES AT THE ASSET

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

The highest priorities for monitoring at Karadoc Swamp are the monitoring questions that most strongly influence watering decisions and the evaluation of watering effectiveness. The monitoring priorities at Karadoc Swamp are shown in Table 18.

Table 18. Monitoring priorities at Karadoc Swamp

Monitoring Priority	Reason for Priority
Water delivery	Adaptive management: water is managed to meet EWMP objectives.
Inundation extent	To ensure inundation does not extend onto private land.
Monitoring of waterbird diversity, abundance, and breeding	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.
Groundwater monitoring	A small groundwater-monitoring program could also be implemented focusing on bores located around the perimeter of Karadoc Swamp target areas. The collection of groundwater level and salinity data will help assess the groundwater response to watering and the level of connection between Karadoc Swmap and the floodplain aquifer.

Black box, river red gum and 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.

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 16 shows an illustration of the adaptive management cycle for environmental water delivery.

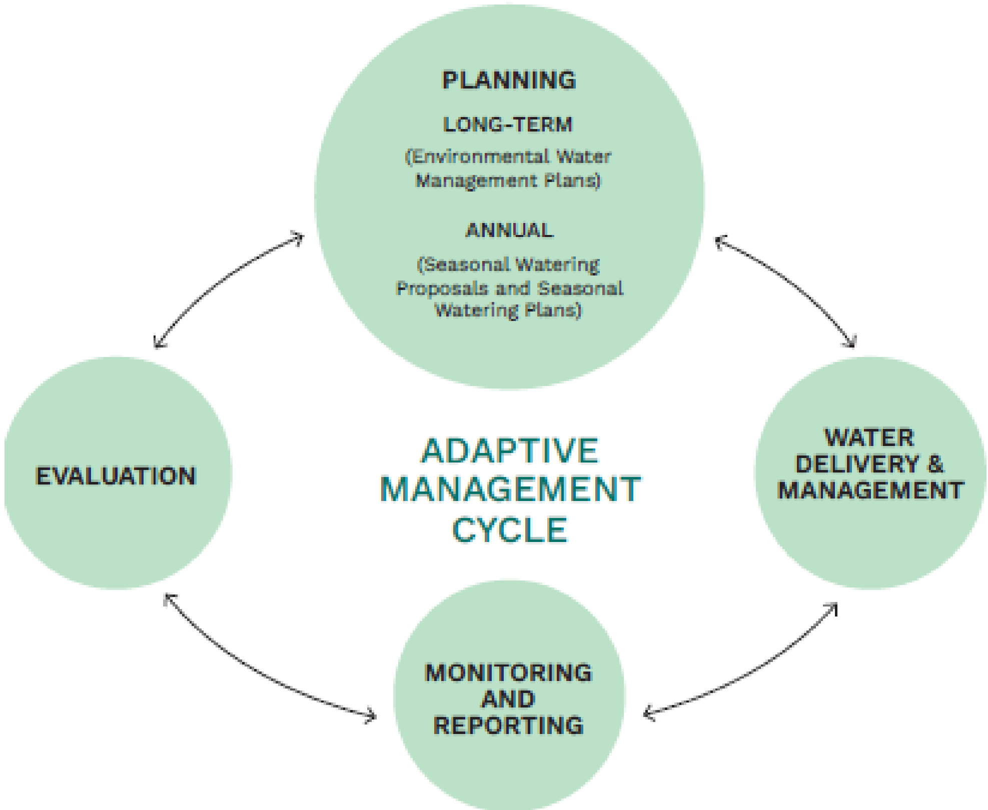

Figure 16. The adaptive management cycle for environmental water delivery and management

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.

In 2022, Mallee CMA further refined its adaptive management approach, implementing the Environmental Watering Adaptive Management Framework (Mallee CMA 2022)

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.

Mallee CMA's 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. In this way, we iteratively improve 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.

11.1 ADAPTIVE MANAGEMENT COMPONENTS

Environmental Watering Database

Mallee CMA uses an Environmental Watering Database for storage of watering information. It stores hydrological, environmental, and ecological watering event details, including data for informing adaptive management decisions.

Annual adaptive management checkpoint

An annual adaptive management checkpoint (AM Checkpoint) for each of Mallee CMA's Seasonal Watering Proposals provides a structured and formalised forum for evaluation and review.

The outcomes from each AM Checkpoint:

- informs the annual reporting to relevant stakeholders, including VEWH and DEECA
- identifies the key lessons from environmental water delivery events throughout the year, to be documented into the Watering Event Lessons (WEL) Record (below)
- informs Mallee CMA environment water annual planning for subsequent years.

Watering Event Lessons (WEL) record

Key decisions and justifications, new knowledge and lessons learned are documented in a 'live', site-specific, centralised, document called a Watering Event Lessons (WEL) Record. The WEL Record provides an opportunity for planning and delivery information to be systematically recorded and retained for subsequent evaluation at the AM Checkpoint (see above).

The WEL Record is also used to capture outcomes and knowledge generated from lesson review at the AM Checkpoint.

WEL Records are updated at the end of each watering event providing an accessible library of lessons ready to be uploaded into the CMA's organisational knowledge base via the EWMP update process.

Seasonal watering proposal presentation adaptive management section

The annual seasonal watering proposals presentation to Mallee CMA Chief Executive Officer and Executive Management includes a section on adaptive management.

This section explicitly focuses on outcomes and observations from previous events and any subsequent changes being made as a response within that years' Seasonal Watering Proposal. This promotes for the broader dissemination of findings and outcomes within Mallee CMA.

Monitoring Consultants' findings summary

Monitoring consultants are required to synthesise their results and describe the implications of results for ongoing environmental watering programs. This promotes the transfer and uptake of knowledge from monitoring and other investigations into Mallee CMA water planning and management.

Figure 16 shows how adaptive management processes are integrated with Mallee CMA's environmental watering program.

12 Knowledge gaps and recommendations

This plan is based on best information at the time of writing. In some cases, this 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 19.

Table 19. Knowledge gaps and recommendations for Karadoc Swamp

Knowledge and data gaps	Action recommended	Responsibility
Impacts of nearby irrigation on wetland health	Investigation of surface water, groundwater and irrigation water interaction	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
Salt loads within the wetlands	Data collection and monitoring	
Role of wetland on waterbird breeding and populations	Data collection and monitoring	
Role of wetland on fish breeding and population	Monitoring of fish population	
Accurate depth and volumes for the wetland	Install depth gauges and bathymetric survey	
Bat population in the area	Monitoring and trapping program	
Extent of Cumbungi infestation within the wetlands	Data collection and monitoring	
Current fauna and flora populations	Surveys, data collection and monitoring	
In-stream salinity impacts (including downstream users)	Salinity Assessment for proposed watering actions	

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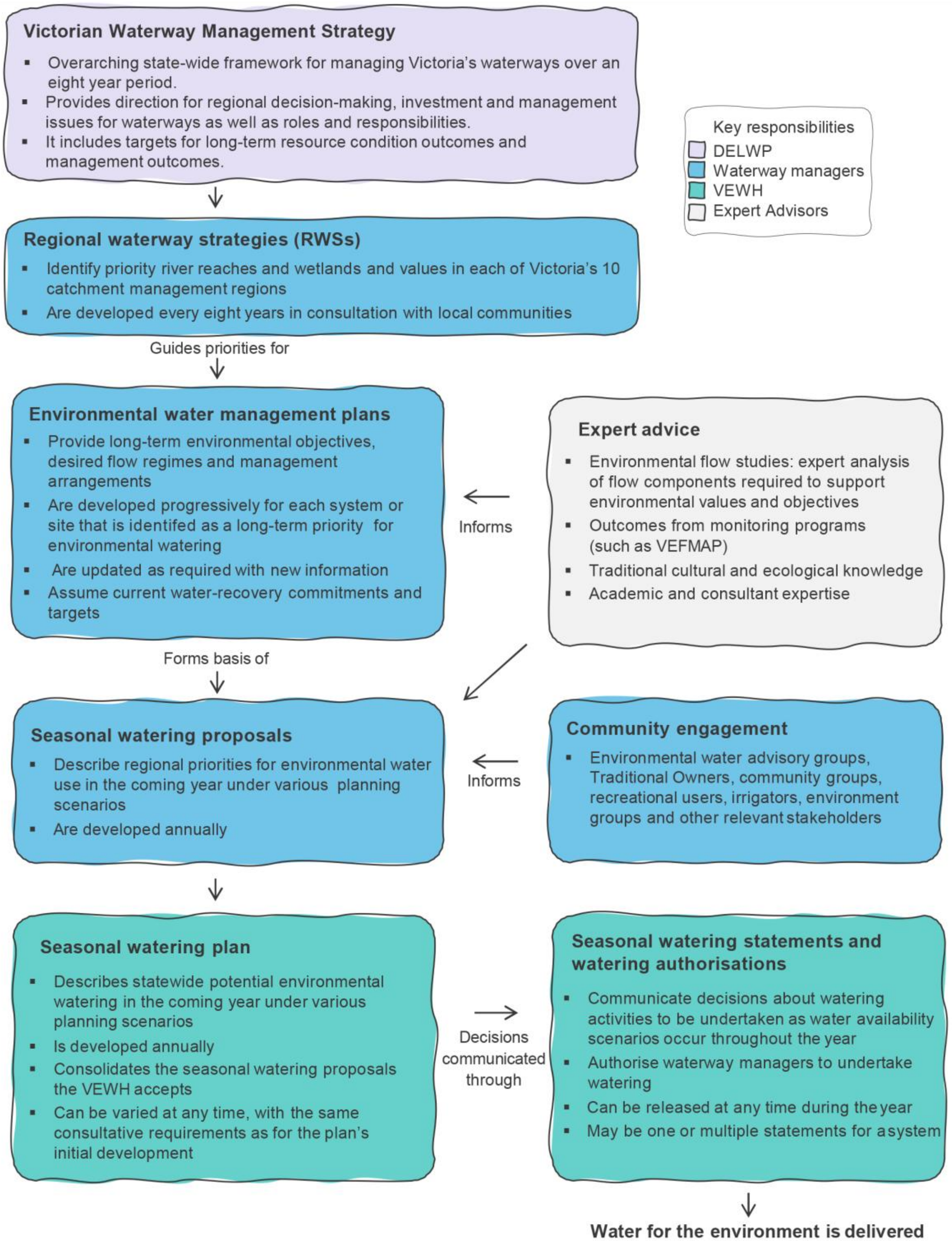
APPENDIX 1.

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 Karadoc Swamp 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 Karadoc Swamp 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 Karadoc Swamp.

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 AGENT ENGAGEMENT 2024-25

Community stakeholders were engaged on the update of this and other EWMPs in-person at local events, including local markets (Red Cliffs Market), local environmental group outings to the site (Mildura Birdlife) and onsite community group events (general community). 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 the sites within the Karadoc Swamp and other WMU subunits. Community consultation occurs at the IAP2 level of CONSULT.

In-person community engagement:

Community stakeholders provided information about Karadoc Swamp at in-person meetings with Mildura Birdlife, and in general community events and markets. These stakeholders had specific interests in birds, recreational activities and water values at the site.

Traditional Owner engagement on Country:

Traditional Owner representatives were engaged on the Karadoc Swamp EWMP at an in-person meeting at Mallee CMA offices in October 2024. Representatives from FPMMAC attended the meeting. A 'pins in maps' exercise was also completed at this meeting. Traditional Owners identified water-dependent values, flora and fauna values (birdlife and native vegetation), recreational values (camping), and other cultural values across Karadoc Swamp. The true extent of cultural heritage at Karadoc Swamp is unknown.

Agency Engagement:

Mallee CMA engaged with representatives from agency stakeholders Parks Victoria, Lower Murray Water, Mildura Rural City Council and Goulburn Murray Water in June 2025 via email and presentation seeking site specific input regarding changes to site condition, site and surrounding land use, known flora and fauna and infrastructure (drainage, bores etc) at the site.

APPENDIX 3.
ECOLOGICAL VEGETATION CLASSES

EVC no.	EVC name	Bioregional Conservation Status	Description
810	Floodway Pond Herbland	Depleted	Low herbland to <0.3m 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.
295	Riverine Grassy Woodland	Depleted	Occurs on the floodplain of major rivers, in a slightly elevated position where floods are rare, on deposited silts and sands, forming fertile alluvial soils. River Red Gum woodland to 20m tall with a ground layer dominated by graminoids and sometimes lightly shrubby or with chenopod shrubs.
106	Grassy Riverine Forest	Depleted	Occurs on the floodplain of major rivers, in a slightly elevated position where floods are infrequent, on deposited silts and sands, forming fertile alluvial soils. River Red Gum Forest to 25m tall with a groundlayer dominated by tussock-forming graminoids. Occasional tall shrubs present.
811	Grassy Riverine Forest / Floodway Pond Herbland Complex	Depleted	Eucalypt forest or woodland of flood-prone areas, where herbaceous species characteristic of drying mud within wetlands (Floodway Pond Herbland or in part Lake Bed Herbland) are conspicuous in association or fine-scale mosaic with Paspalidium jubiflorum and other species characteristic of Grassy Riverine Forest. Restricted extent, Murray River system mainly in far north-west, but upstream at least as far as Barmah Forest.
104	Lignum Swamp	Vulnerable	Typically, treeless shrubland to 4m tall, with robust (but sometimes patchy) growth of lignum. Widespread wetland vegetation type in low rainfall area on heavy soils, subject to infrequent inundation resulting from overbank flows from rivers or local runoff.
823	Lignum Swampy Woodland	Depleted	Understorey dominated by Lignum, typically of robust character and relatively dense (at least in patches), in association with a low Eucalypt and/or Acacia woodland to 15 m tall. The ground layer includes a component of obligate wetland flora that is able to persist even if dormant over dry periods.
808	Lignum Shrubland	Least Concern	Relatively open shrubland of species of divaricate growth form. The ground-layer is typically herbaceous or a turf grassland, rich in annual/ephemeral herbs and small chenopods. Characterised the open and even distribution of relatively small Lignum shrubs. Occupies heavy soil plains along Murray River, low-lying areas on higher-level (but still potentially flood-prone) terraces.

EVC no.	EVC name	Bioregional Conservation Status	Description
818	Shrubby Riverine Woodland	Least Concern	Eucalypt woodland to open forest to 15 m tall of less flood-prone (riverine) watercourse fringes, principally on levees and higher sections of point-bar deposits. The understorey includes a range of species shared with drier floodplain habitats with a sparse shrub component, ground-layer patchily dominated by various life-forms. A range of large dicot herbs (mostly herbaceousperennial, several with a growth-form approaching that of small shrub) are often conspicuous.
813	Intermittent Swampy Woodland	Depleted	Eucalypt woodland to 15 m tall with a variously shrubby and rhizomatous sedgy – turf grass understorey, at best development dominated by flood stimulated species in association with flora tolerant of inundation. Flooding is unreliable but extensive when it happens. Occupies low elevation areas on river terraces (mostly at the rear point-bar deposits or adjacent to major floodways) and lacustrine verges (where sometimes localised to narrow transitional bands). Soils often have a shallow sand layer over heavy and frequently slightly brackish soils.
107	Lakebed Herbland	Depleted	Herbland or shrubland to 0.5m tall dominated by species adapted to drying mud within lake beds. Some evade periods of prolonged inundation as seed, others as dormant tuber-like rootstock. Occupies drying deep-cracking mud of lakes on floodplains, floods are intermittent but water may be retained for several seasons leading to active growth at the 'drying mud stage'.
200	Shallow Freshwater Marsh	Vulnerable	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.
103	Riverine Chenopod Woodland	Depleted	Eucalypt woodland to 15m 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.

APPENDIX 4.

FAUNA SPECIES LIST – COMBINED NATUREKIT, BIRD OBSERVATIONS AND PROTECTED MATTERS SEARCHES

Scientific name	Common Name	FFG Act Status	EPBC Act Status
Cherax destructor destructor	Common Yabby		
Paratya spp	Freshwater Shrimp		
Macrobrachium	Freshwater Prawn		
Melanotaenia fluviatilis	Murray-Darling Rainbow fish	Endangered	
Macquaria ambigua	Golden Perch		
Hypseleotris spp	Carp Gudgeon		
Craterocephalus stercusmuscarum	Fly-specked hardyhead		
Nematalosa erebi	Bony Bream		
Chelodina longicollis	Eastern Long-Necked Turtle		
Microcarbo melanoleucos	Little Pied Cormorant		
Cracticus nigrogularis	Pied Butcherbird		
Dromaius novaehollandiae	Emu		
Coturnix pectoralis	Stubble Quail		
Geopelia striata	Peaceful Dove		
Phaps chalcoptera	Common Bronzewing		
Ocyphaps lophotes	Crested Pigeon		
Leucosarcia melanoleuca	Wonga Pigeon		
Porzana fluminea	Australian Spotted Crake		
Gallinula ventralis	Black-tailed Native-hen		
Gallinula tenebrosa	Dusky Moorhen		
Porphyrio porphyrio	Purple Swamphen		
Fulica atra	Eurasian Coot		
Podiceps cristatus	Great Crested Grebe		
Tachybaptus novaehollandiae	Australasian Grebe		
Phalacrocorax carbo	Great Cormorant		
Phalacrocorax sulcirostris	Little Black Cormorant		
Phalacrocorax varius	Pied Cormorant		
Anhinga novaehollandiae	Darter		
Pelecanus conspicillatus	Australian Pelican		
Hydroprogne caspia	Caspian Tern	Vulnerable	
Chroicocephalus novaehollandiae	Silver Gull		
Erythrogonys cinctus	Red-kneed Dotterel		

Scientific name	Common Name	FFG Act Status	EPBC Act Status
Vanellus miles	Masked Lapwing		
Vanellus tricolor	Banded Lapwing		
Charadrius ruficapillus	Red-capped Plover		
Elseyornis melanops	Black-fronted Dotterel		
Calidris ruficollis	Red-necked Stint		
Calidris acuminata	Sharp-tailed Sandpiper		
Calidris tenuirostris	Great Knot	Critically endangered	
Calidris alba	Sanderling		
Grus rubicunda	Brolga	Endangered	
Plegadis falcinellus	Glossy Ibis		
Threskiornis molucca	Australian White Ibis		
Threskiornis spinicollis	Straw-necked Ibis		
Platalea regia	Royal Spoonbill		
Platalea flavipes	Yellow-billed Spoonbill		
Ardea intermedia	Intermediate Egret	Critically endangered	
Ardea modesta	Eastern Great Egret	Vulnerable	
Egretta novaehollandiae	White-faced Heron		
Ardea pacifica	White-necked Heron		
Nycticorax caledonicus hillii	Nankeen Night Heron		
Chenonetta jubata	Australian Wood Duck		
Cygnus atratus	Black Swan		
Tadorna tadornoides	Australian Shelduck		
Anas superciliosa	Pacific Black Duck		
Anas gracilis	Grey Teal		
Anas rhynchotis	Australasian Shoveler	Vulnerable	
Malacorhynchus membranaceus	Pink-eared Duck		
Aythya australis	Hardhead		
Oxyura australis	Blue-billed Duck	Vulnerable	
Biziura lobata	Musk Duck	Vulnerable	
Circus approximans	Swamp Harrier		
Accipiter fasciatus	Brown Goshawk		
Accipiter cirrhocephalus	Collared Sparrowhawk		
Aquila audax	Wedge-tailed Eagle		
Hieraaetus morphnoides	Little Eagle		

Scientific name	Common Name	FFG Act Status	EPBC Act Status
Haliaeetus leucogaster	White-bellied Sea-Eagle	Endangered	
Haliastur sphenurus	Whistling Kite		
Milvus migrans	Black Kite		
Elanus axillaris	Black-shouldered Kite		
Falco longipennis	Australian Hobby		
Falco peregrinus	Peregrine Falcon		
Falco cenchroides	Nankeen Kestrel		
Ninox novaeseelandiae	Southern Boobook		
Tyto javanica	Pacific Barn Owl		
Cacatua galerita	Sulphur-crested Cockatoo		
Lophocroa leadbeateri	Major Mitchell's Cockatoo		
Cacatua sanguinea	Little Corella		
Eolophus roseicapilla	Galah		
Nymphicus hollandicus	Cockatiel		
Polytelis anthopeplus monarchoides	Regent Parrot	Vulnerable	
Platycercus elegans	Crimson Rosella		
Platycercus adscitus	Pale-headed Rosella		
Psephotus haematonotus	Red-rumped Parrot		
Psephotus varius	Mulga Parrot		
Northiella haematogaster	Blue Bonnet		
Melopsittacus undulatus	Budgerigar		
Podargus strigoides	Tawny Frogmouth		
Aegotheles cristatus	Australian Owlet-nightjar		
Dacelo novaeguineae	Laughing Kookaburra		
Todiramphus macleayii	Forest Kingfisher		
Todiramphus pyrropygia pyrropygia	Red-backed Kingfisher		
Todiramphus sanctus	Sacred Kingfisher		
Merops ornatus	Rainbow Bee-eater		
Cuculus pallidus	Pallid Cuckoo		
Cacomantis flabelliformis	Fan-tailed Cuckoo		
Chrysococcyx basalis	Horsfield's Bronze-Cuckoo		
Petrochelidon neoxena	Welcome Swallow		
Cheramoeca leucosternus	White-backed Swallow		
Petrochelidon nigricans	Tree Martin		

Scientific name	Common Name	FFG Act Status	EPBC Act Status
Petrochelidon ariel	Fairy Martin		
Rhipidura albiscarpa	Grey Fantail		
Rhipidura leucophrys	Willie Wagtail		
Myiagra inquieta	Restless Flycatcher		
Petroica goodenovii	Red-capped Robin		
Melanodryas cucullata cucullata	Hooded Robin		
Pachycephala rufiventris	Rufous Whistler		
Colluricincla harmonica	Grey Shrike-thrush		
Grallina cyanoleuca	Magpie-lark		
Falcunculus frontatus	Crested Shrike-tit		
Oreoica gutturalis gutturalis	Crested Bellbird		
Coracina maxima	Ground Cuckoo-shrike		
Coracina novaehollandiae	Black-faced Cuckoo-shrike		
Lalage sueurii	White-winged Triller		
Cinclosoma castanotus	Chestnut Quail-thrush		
Pomatostomus superciliosus	White-browed Babbler		
Pomatostomus ruficeps	Chestnut-crowned Babbler		
Epthianura albifrons	White-fronted Chat		
Epthianura tricolor	Crimson Chat		
Gerygone fusca	Western Gerygone		
Smicrornis brevirostris	Weebill		
Aphelocephala leucopsis	Southern Whiteface		
Acanthiza nana	Yellow Thornbill		
Acanthiza uropygialis	Chestnut-rumped Thornbill		
Acanthiza chrysorrhoa	Yellow-rumped Thornbill		
Megalurus gramineus	Little Grassbird		
Acrocephalus stentoreus	Clamorous Reed Warbler		
Stipiturus mallee	Mallee Emu-wren		
Malurus cyaneus	Superb Fairy-wren		
Malurus splendens	Splendid Fairy-wren		
Malurus leucopterus	White-winged Fairy-wren		
Malurus lamberti	Variegated Fairy-wren		
Artamus leucorynchus	White-breasted Woodswallow		
Artamus personatus	Masked Woodswallow		

Scientific name	Common Name	FFG Act Status	EPBC Act Status
Artamus superciliosus	White-browed Woodswallow		
Artamus cinereus	Black-faced Woodswallow		
Artamus cyanopterus	Dusky Woodswallow		
Daphoenositta chrysoptera	Varied Sittella		
Climacteris affinis	White-browed Treecreeper		
Dicaeum hirundinaceum	Mistletoebird		
Zosterops lateralis	Silvereye		
Plectorhyncha lanceolata	Striped Honeyeater		
Sugamel niger	Black Honeyeater		
Phylidonyris albifrons	White-fronted Honeyeater		
Certhionyx variegatus	Pied Honeyeater		
Lichenostomus virescens	Singing Honeyeater		
Lichenostomus chrysops	Yellow-faced Honeyeater		
Lichenostomus penicillatus	White-plumed Honeyeater		
Manorina melanocephala	Noisy Miner		
Manorina flavigula	Yellow-throated Miner		
Acanthagenys rufogularis	Spiny-cheeked Honeyeater		
Entomyzon cyanotis	Blue-faced Honeyeater		
Philemon citreogularis	Little Friarbird		
Anthus novaeseelandiae	Australasian Pipit		
Stagonopleura guttata	Diamond Firetail		
Taeniopygia guttata	Zebra Finch		
Ptilonorhynchus maculatus	Spotted Bowerbird		
Corcorax melanorhamphos	White-winged Chough		
Strepera versicolor	Grey Currawong		
Cracticus torquatus	Grey Butcherbird		
Gymnorhina tibicen	Australian Magpie		
Corvus coronoides	Australian Raven		
Corvus mellori	Little Raven		
Pardalotus striatus	Striated Pardalote		
Tachyglossus aculeatus	Short-beaked Echidna		
Pseudocheirus peregrinus	Common Ringtail Possum		
Acrobates pygmaeus	Feathertail Glider		
Macropus fuliginosus	Western Grey Kangaroo		

Scientific name	Common Name	FFG Act Status	EPBC Act Status
Isoodon sp. (c.f. auratus)	Short-nosed Bandicoot (inland form)		
Christinus marmoratus	Marbled Gecko		
Limnodynastes fletcheri	Barking Marsh Frog		
Limnodynastes tasmaniensis	Spotted Marsh Frog		
Crinia parinsignifera	Plains Froglet		
Litoria peronii	Peron's Tree Frog		
Platycercus elegans flaveolus	Yellow Rosella		
Barnardius zonarius barnardi	Mallee Ringneck		
Climacteris picumnus victoriae	Brown Treecreeper (south-eastern ssp.)		
Himantopus himantopus	Black-winged Stilt		
DEECA 2025, DCCEW 2024			

FLORA SPECIES LIST - COMBINED NATUREKIT, VICTORIAN BIODIVERSITY ALTAS WITH RESULTS OF A WETMAP FLORA SURVEY (WETMAP 2024)

Scientific Name	Common Name	FFG Act Status	EPBC Act Status
Eremophila divaricata subsp. divaricata	Spreading Emu-bush	Vulnerable	
Maireana decalvans s.l.	Black Cotton-bush		
Minuria denticulata	Woolly Minuria	Endangered	
Acacia stenophylla	Eumong		
Actinobole uliginosum	Flannel Cudweed		
Lachnagrostis filiformis s.l.	Common Blown-grass		
Amaranthus macrocarpus var. macrocarpus	Dwarf Amaranth	Endangered	
Aristida contorta	Sand Wire-grass		
Atriplex lindleyi subsp. inflata	Corky Saltbush		
Atriplex leptocarpa	Slender-fruit Saltbush		
Atriplex lindleyi	Flat-top Saltbush		
Atriplex papillata	Coral Saltbush	Vulnerable	
Atriplex semibaccata	Berry Saltbush		
Atriplex stipitata	Kidney Saltbush		
Osteocarpum acropterum var. deminutum	Babbagia		
Bergia trimera	Small Water-fire	Endangered	
Bolboschoenus caldwellii	Salt Club-sedge		
Brachyscome ciliaris	Variable Daisy		
Brachyscome lineariloba	Hard-head Daisy		
Bulbine semibarbata	Leek Lily		
Calandrinia eremaea	Small Purslane		
Calocephalus sonderi	Pale Beauty-heads		
Calotis hispidula	Hairy Burr-daisy		
Carpobrotus modestus	Inland Pigface		
Casuarina obesa	Swamp Sheoak	Critically endangered	
Euphorbia drummondii	Flat Spurge		
Dysphania cristata	Crested Goosefoot		
Chenopodium curvispicatum	Cottony Saltbush		
Chenopodium nitrariaceum	Nitre Goosefoot		
Crassula colorata	Dense Crassula		
Crassula sieberiana s.l.	Sieber Crassula		
Cressa australis	Rosinweed		
Cymbonotus lawsonianus	Bear's-ear		
Cynodon dactylon	Couch		
Cynoglossum australe	Australian Hound's-tongue		
Cyperus gymnocaulos	Spiny Flat-sedge		
Disphyma crassifolium subsp. clavellatum	Rounded Noon-flower		
Dodonaea viscosa	Sticky Hop-bush		
Eclipta platyglossa subsp. platyglossa	Yellow Twin-heads		
Einadia nutans	Nodding Saltbush		
Enchylaena tomentosa var. tomentosa	Ruby Saltbush		
Sphaeromorphaea australis	Spreading Nut-heads		

Scientific Name	Common Name	FFG Act Status	EPBC Act Status
Eragrostis australasica	Cane Grass	Critically endangered	
Eragrostis dielsii	Mallee Love-grass		
Eragrostis lacunaria	Purple Love-grass	Endangered	
Eragrostis setifolia	Bristly Love-grass	Endangered	
Eremophila longifolia	Berrigan		
Eucalyptus camaldulensis	River Red-gum		
Eucalyptus largiflorens	Black Box		
Eulalia aurea	Silky Browntop		
Gnaphalium polycaulon	Indian Cudweed		
Goodenia glauca	Pale Goodenia		
Haloragis aspera	Rough Raspwort		
Tecticornia pergranulata	Blackseed Glasswort		
Triptilodiscus pygmaeus	Common Sunray		
Rhodanthe pygmaea	Pygmy Sunray		
Juncus aridicola	Tussock Rush		
Lepidium pseudohyssopifolium	Native Peppercress	Endangered	Endangered
Maireana brevifolia	Short-leaf Bluebush		
Maireana pentagona	Hairy Bluebush		
Maireana pentatropis	Erect Bluebush		
Maireana pyramidata	Sago Bush		
Eriochiton sclerolaenoides	Woolly-fruit Bluebush		
Maireana triptera	Three-wing Bluebush		
Marsilea drummondii	Common Nardoo		
Mimulus repens	Creeping Monkey-flower		
Duma florulenta	Tangled Lignum		
Myriocephalus rhizocephalus	Woolly-heads		
Polycalymma stuartii	Poached-eggs Daisy		
Olearia pimeleoides	Pimelea Daisy-bush		
Oxalis perennans	Grassland Wood-sorrel		
Paspalidium jubiflorum	Warrego Summer-grass		
Pittosporum angustifolium	Weeping Pittosporum		
Plantago drummondii	Dark Plantain		
Plantago turrifera	Crowned Plantain		
Podolepis capillaris	Wiry Podolepis		
Cullen tenax	Tough Scurf-pea	Endangered	
Ptilotus nobilis var. nobilis	Yellow Tails	Endangered	
Ranunculus pentandrus var. platycarpus	Inland Buttercup		
Rhagodia spinescens	Hedge Saltbush		
Salsola tragus	Prickly Saltwort		
Sarcozona praecox	Sarcozona		
Sclerochlamys brachyptera	Short-wing Saltbush		
Sclerolaena diacantha	Grey Copperburr		
Sclerolaena obliquicuspis	Limestone Copperburr		
Sclerolaena tricuspis	Streaked Copperburr		
Senecio glossanthus s.l.	Slender Groundsel		
Senecio pinnatifolius	Variable Groundsel		

Scientific Name	Common Name	FFG Act Status	EPBC Act Status
Sida ammophila	Sand Sida		
Sida corrugata	Variable Sida		
Solanum esuriale	Quena		
Spergularia media s.l.	Coast Sand-spurrey		
Sporobolus caroli	Yakka Grass	Endangered	
Sporobolus mitchellii	Rat-tail Couch		
Stelligera endecaspinis	Star Bluebush		
Austrostipa scabra subsp. falcata	Rough Spear-grass		
Austrostipa nitida	Balcarra Spear-Grass		
Swainsona microphylla	Small-leaf Swainson-pea		
Teucrium racemosum s.l.	Grey Germander		
Triglochin calcitrapa s.l.	Spurred Arrowgrass		
Triglochin nana	Dwarf Arrowgrass		
Vittadinia cervicularis	Annual New Holland Daisy		
Vittadinia cuneata	Fuzzy New Holland Daisy		
Vittadinia dissecta s.l.	Dissected New Holland Daisy		
Vittadinia gracilis	Woolly New Holland Daisy		
Wahlenbergia communis s.l.	Tufted Bluebell		
Wahlenbergia fluminalis	River Bluebell		
Zygophyllum glaucum	Pale Twin-leaf		
Atriplex pumilio	Mat Saltbush		
Amphibromus nervosus	Common Swamp Wallaby-grass		
Eragrostis infecunda	Southern Cane-grass		
Phyllanthus lacunellus	Sandhill Spurge		
Wahlenbergia tumidifructa	Mallee Annual-bluebell		
Zygophyllum eremaeum	Climbing Twin-leaf		
Brachyscome ciliaris var. ciliaris	Variable Daisy		
Dodonaea viscosa subsp. angustissima	Slender Hop-bush		
Epilobium billardierianum subsp. cinereum	Grey Willow-herb		
Atriplex spinibractea	Spiny-fruit Saltbush	Endangered	
Stemodia florulenta	Blue Rod		
Picris squarrosa	Squat Picris		
Swainsona reticulata	Kneed Swainson-pea	Endangered	
Sclerolaena muricata var. villosa	Grey Roly-poly		
Sida corrugata var. angustifolia	Variable Sida (narrow-lf form)		
Sclerolaena muricata var. muricata	Black Roly-poly		
Vittadinia cervicularis var. subcervicularis	Annual New Holland Daisy		
Vittadinia dissecta var. hirta	Dissected New Holland Daisy		
Alternanthera denticulata s.s.	Lesser Joyweed		
Spergularia brevifolia	Salt Sea-spurrey		
Eriochlamys behrii s.s.	Woolly Mantle		
Einadia nutans (matted form)	Nodding Saltbush (matted form)		
Poaceae spp.	Grass		

Scientific Name	Common Name	FFG Act Status	EPBC Act Status
Agrostis s.l. spp.	Bent/Blown Grass		
Atriplex spp.	Saltbush		
Dodonaea spp.	Hop Bush		
Eragrostis spp.	Love Grass		
Euphorbia spp.	Spurge		
Goodenia spp.	Goodenia		
Lepidium spp.	Peppercress		
Marsilea spp.	Nardoo		
Paspalidium spp.	Panic Grass		
Sclerolaena spp.	Copperburr		
Austrostipa spp.	Spear Grass		
Swainsona spp.	Swainson Pea		
Vittadinia spp.	New Holland Daisy		

APPENDIX 5.

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 prioritization, 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	

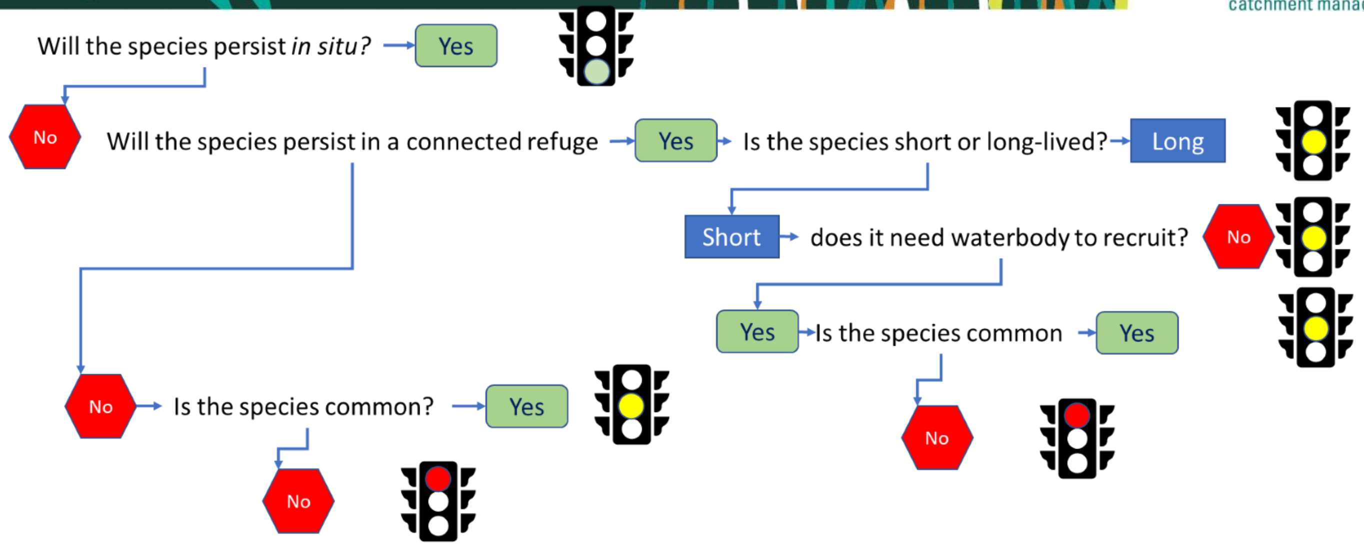


Figure A1 – Decision tree for assessing risk

APPENDIX 7.

EWMP UPDATED ENVIRONMENTAL OBJECTIVES, FURTHER INFORMATION 9FROM BUTCHER ET AL. 2020)

5.11 Karadoc

5.11.1 SMARTness and rationalisation

Site-specific environmental objectives for the Karadoc EWMP (Mallee CMA 2015a).

EWMP objectives
K1: Establish and maintain a refuge habitat for Murray Hardyhead: ▪ Improve aquatic vegetation structure ▪ Manage salinity levels within wetland chosen for Murray Hardyhead
K2: Improve vegetation health and structure in the fringing Lignum, Black Box and River Red Gum woodlands
K3: Provide habitat for small bodied native fish
K4: Provide suitable habitat for native frog species ▪ Manage salinity levels within all wetlands considering the wetland chosen for Murray Hardyhead
K5: Provide suitable feeding and breeding habitat for various waterbird guilds
K6: Improve the health of the Swamp Sheoak community around Karadoc Swamp
K7: Improve the health of Black Box communities
K8: Provide suitable foraging and roosting habitat for Microbats

Assessment of SMARTness of current Karadoc 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
K1	0	0	1	1	1	0.5	0.5	1	1	0	0
K2	0	0	1	1	1	0.5	1	1	1	0	0
K3	0	0	1	1	0.5	0.5	1	1	1	0	0
K4	0	0	1	1	1	0.5	1	1	0.5	0	0
K5	0	0	1	1	1	0.5	1	1	1	0	0
K6	0	0	1	1	1	0.5	1	1	0.5	0	0
K7	0	0	1	1	1	0.5	1	1	1	0	0
K8	0	0	1	1	1	0.5	1	0.5	0	0	0

Rationalised environmental objectives for the Karadoc EWMP (Mallee CMA 2015a).

Objective	Issue	Outcome
K1	Not considered viable by MCMA; Murray hardyhead do not inhabit region. Vegetation outcome will be achieved by providing habitat for frogs (K4) and feeding habitat for waterbirds (K5)	Delete
K2	No issue with objective other than its not fully SMART	Objective updated to align with Basin Plan language
K3	No issue with objective other than its not fully SMART	Objective updated to align with Basin Plan language
K4	Salinity element not considered relevant in terms of supporting Murray Hardyhead as this is no longer an objective for the site	Focus on frog species only
K5	No issue with objective other than its not fully SMART	Objective updated to align with Basin Plan language
K6	Unlikely to be able to water the community/asset due to downstream salinity returns and location (elevation outside area of influence. Population was all the same gender, so there is no reproduction occurring (Ian Sluiter pers. comm.). Now critically endangered	Deleted
K7	No issue with objective other than its not fully SMART	Objective updated to align with Basin Plan language
K8	Not considered viable by MCMA. Microbats are considered terrestrial and are not directly dependent on environmental water	Delete

5.11.2 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, ROKAMBA, BONN **3:** High habitat diversity **4:** FFG Act, EPBC act, DSE Listed **5:** Has previously supported significant biodiversity	**1:** Supports the creation and maintenance of vital habitats and populations **2:** water quality - ecosystem processes support 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(e):** Vital habitat - preventing decline of native biota

3(a)i: Vital habitat - refugium during dry spells and drought **4(a):** EPBC listed spp and communities **4(b):** State listed ecosystems	**1(c):** Vital habitat - feeding, breeding, nursery sites

Mapping Karadoc 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
K1: Establish and maintain a refuge habitat for Murray Hardyhead: • Improve aquatic vegetation structure • Manage salinity levels within wetland chosen for Murray Hardyhead	8.05,3(a)	Condition of priority asset - Vital habitat – refugia Condition of priority asset - supports listed species and communities	None specified	LTWPVM16
K2: Improve vegetation health and structure in the fringing Lignum, Black Box and River Red Gum woodlands	8.05,3(b) 8.06,6(b)	Condition of priority asset – prevention of decline of native biota Condition of native water-dependent vegetation	B2.8	LTWPVM5 LTWPVM6 LTWPVM8
K3: Provide habitat for small bodied native fish	8.06,6(b)	Condition of priority ecosystem functions - creation of vital habitat - diversity of habitat	B4.5	LTWPVM15
K4: Provide suitable habitat for native frog species Manage salinity levels within all wetlands considering the wetland chosen for Murray Hardyhead	8.06,2 8.05,3(b) 8.06,6(b)	Condition of priority asset - prevention of decline in native biota Condition of priority ecosystem functions - creation of vital habitat - habitat for prevention of decline in native species Condition of priority ecosystem functions - creation of vital habitat - feeding, breeding, nursery	None specified	LTWPVM19
K5: Provide suitable feeding and breeding habitat for various waterbird guilds				
K6: Improve the health of the Swamp Sheoak community around Karadoc Swamp	8.05,3(a)	Condition of priority asset - supports listed species and communities	None specified	None specified
K7: Improve the health of Black Box communities	8.05,3(b) 8.06,6(b)	Condition of priority asset – prevention of decline of native biota Condition of native water-dependent vegetation	B2.9	LTWPVM5

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		
K8: Provide suitable foraging and roosting habitat for Microbats	Not applicable	Not applicable	Not applicable	Not applicable

5.11.3 Updated objectives for Karadoc

Current objective	K1: Establish and maintain a refuge habitat for Murray Hardyhead: • Improve aquatic vegetation structure • Manage salinity levels within wetland chosen for Murray Hardyhead
Comments	Deleted

Current objective	K2: Improve vegetation health and structure in the fringing Lignum, Black Box and River Red Gum woodlands
Comments	May need to simplify or split this objective.
EWP objective(s)	8.05,3(b)
Schedule 7 targets	Condition of priority asset - prevention of decline in native biota Diversity of native water dependent vegetation
PEA/PEF criteria met	PEA 3(b) Prevents declines in native biota PEF 1(e) Vital habitat - preventing decline of native biota
BWS QEEO	B2.8 By 2024 improve condition of Black Box and river red gum
LTWP objective	LTWPVM8 Improve the condition of shrub and lignum dominated EVCs LTWPVM5 Improve the condition of river red gum dominated EVCs LTWPVM6 Improve the condition of Black Box 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 A positive trend in the condition score of Black Box dominated EVC benchmarks at 50% of sites over the 10-year period to 2025

	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*), River Red Gum (*Eucalyptus camaldulensis*), and Black Box (*E. largiflorens*) and to sustain communities and processes reliant on such communities at Burra Creek
2020 Targets:	By 2030, condition in standardised transects that span the floodplain elevation gradient and existing spatial distribution at the Karadoc asset, ≥70% of Lignum plants in good condition with a Lignum Condition Score (LCI) ≥4. **AND** By 2030, a positive trend in the condition score of River Red Gum dominated EVC benchmarks at the Karadoc asset at 80% of sites over the 10-year period. OR By 2030, at stressed sites (see Wallace et al. 2020) at the Karadoc asset: 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 River Red Gum trees at needs to be established. **AND** By 2030 a positive trend in the condition score of Black Box dominated EVC benchmarks at the Karadoc asset at 80% of sites over the 10-year period OR By 2030, at stressed sites (see Wallace et al. 2020) at the Karadoc asset: 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 by 2030

Current objective	**K3: Provide habitat for small bodied native fish**
Comments	Rather than a focus only on habitat, the objective has been updated to also include representative populations of species recorded at the asset (Murray-Darling Rainbow Fish, Carp Gudgeon and Fly-specked Hardyhead).
EWP objective(s)	8.06,6(b)
Schedule 7 targets	Condition of priority ecosystem functions - creation of vital habitat - diversity of habitat
PEA/PEF criteria met	PEA criterion 3(b) Prevents declines in native biota
BEWS QEEO	4.5 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 populations at the Karadoc asset, including Murray-Darling Rainbow Fish (*Melanotaenia fluviatilis*), Carp Gudgeon (*Hypseleotris* spp) and Fly-specked Hardyhead (*Craterocephalus stercusmuscarum*).

2020 Targets:	By 2030, maintain self-sustaining populations Murray-Darling Rainbow Fish (*Melanotaenia fluviatilis*), Carp Gudgeon (*Hypseleotris* spp) and Fly-specked Hardyhead (*Craterocephalus stercusmuscarum*) at the Karadoc asset. Measured as: • Adults or YoY for each species recorded in 8 out of 10 years

Current objective	**K4: Provide suitable habitat for native frog species** • **Manage salinity levels within all wetlands considering the wetland chosen for Murray Hardyhead**
Comments	Salinity element not considered relevant in terms of supporting Murray Hardyhead as this is no longer an objective for the site. This objective is solely about the frog population
EWP objective(s)	8.05,3(b) 8.06,6(b)
Schedule 7 targets	Condition of priority asset - prevention of decline in native biota Condition of priority ecosystem functions - creation of vital habitat - habitat for prevention of decline in native species Condition of priority ecosystem functions - creation of vital habitat - feeding, breeding, nursery
PEA/PEF criteria met	PEA 3(b) Prevents declines in native biota PEF 1(e) Vital habitat - preventing decline of native biota PEF 1(c) Vital habitat - feeding, breeding, nursery sites
BWS QEEO	None specified
LTWP objective	LTWPVM19 Improve habitat for frog communities
LTWP target	Maintain the number of native frog species recorded in 80% of years to 2025 (no target for habitat)
2020 Objective:	By 2030, protect and restore biodiversity by maintaining representative populations of frogs at Karadoc Swamp, Karadoc.
2020 Targets:	By 2030, vital habitat (breeding) for frogs at Karadoc Swamp, Karadoc supports the following species: Barking Marsh Frog (*Limnodynastes fletcheri*), Spotted Marsh Frog (*Limnodynastes tasmaniensis*), Plains Froglet (*Crinia parinsignifera*), and Peron's Tree Frog (*Litoria peronii)* in 80% of years.

Current objective	**K5: Provide suitable feeding and breeding habitat for various waterbird guilds**
Comments	
EWP objective(s)	8.05,3(b)
Schedule 7 targets	Condition of priority asset - Vital habitat - feeding, breeding, nursery

PEA/PEF criteria met	PEA 3(a) iii Vital habitat - feeding, breeding, nursery sites PEF 1 (c) Vital habitat - feeding, breeding, nursery sites
BEWS QEEO	B3.1 That the number and type of water bird species present in the Basin will not fall below current observations
LTWP objective	LTWPVM12: Improve habitat for waterbirds LTWPVM13: Improve feeding areas for waterbirds
LTWP target	Appropriate water regime to support feeding and habitat areas for guilds of waterbirds delivered at 50% of sites, 8 years in 10
2020 Objective K5a:	By 2030, maintain representative populations of shallow-water and deep-water feeding guilds of waterbird (F2 and F3, respectively, after Jaensch 2002) at the Karadoc asset, by maintaining a mixture of shallow and deep-water habitats.
2020 Targets K5a:	By 2030, 80% of representative F2 and F3 species recorded at the Karadoc asset in 8 years out of any 10-year period where conditions are suitable. • Representative F2 species include: Australasian Grebe (*Tachybaptus novaehollandiae*), Pacific Black Duck (*Anas superciliosa*), White-necked Heron (*Ardea pacifica*), Australian White Ibis (*Threskiornis molucca*), Masked Lapwing (*Vanellus miles*). • Representative F3 species include: Australian Pelican (*Pelecanus conspicillatus*), Great Cormorant (*Phalacrocorax carbo*), Little Black Cormorant (*Phalacrocorax sulcirostris*), Australian Darter (*Anhinga novaehollandiae*) • Feeding habitat defined as a mixture of deep feeding areas (water >1 m) and shallow feeding areas (<0.5 m depth and or drying mud) with intermittent inundation of densely vegetated shrublands.
Comments	
EWP objective(s)	8.06,6(b) 8.05,3(b)
Schedule 7 targets	Recruitment and populations of native water-dependent birds Condition of native water dependent vegetation
PEA/PEF criteria met	PEA 3(a) iii Vital habitat - feeding, breeding, nursery sites PEA 3(b) Prevents declines in native biota PEF 1 (c) Vital habitat - feeding, breeding, nursery sites
BEWS QEEO	B3.4 Breeding abundance (nests and broods) for all of the other functional groups to increase by 30-40% compared to the baseline scenario, especially in locations where the Basin Plan improves over bank flows
LTWP objective	LTWPVM11: Improve breeding opportunities for waterbirds
LTWP target	No target specified for non-colonial breeding species.
2020 Objective K5b:	By 2030, maintain nesting and recruitment of non-colonial waterbirds (N1, N2, N3 and N4, after Jaensch 2002) at the Karadoc asset, by maintaining a mixture of tree, low vegetation/shrubs, and ground/islet nesting habitat.
2020 Targets K5b:	There is a lack of data on species that breed at the site. The expectation is that the list of species commonly nesting at the Karadoc asset will be confirmed over time.

	By 2030, at least two of the following species to be recorded as nesting and/or breeding at the Karadoc asset in 7 out of any 10-year period in which nesting/breeding conditions are suitable: Representative N1 and N2 species include: White-bellied Sea Eagle (*Haliaeetus leucogaster*), Representative N3 and N4 species include: Australasian Grebe (*Tachybaptus novaehollandiae*), Masked Lapwing (*Vanellus miles*), Pacific Black Duck (*Anas superciliosa*)

Current objective	K6: Improve the health of the Swamp Sheoak community around Karadoc Swamp
Comments	Deleted

Current objective	K7: Improve the health of Black Box communities
Comments	Objective updated to align with Basin Plan language.
EWP objective(s)	8.05,3(b)
Schedule 7 targets	Condition of priority asset – prevention of decline of native biota Condition of native water-dependent vegetation
PEA/PEF criteria met	PEA 3(b) Prevents declines in native biota
BWS QEEO	B2.8 By 2024 improve condition of Black Box and river red gum
LTWP objective	LTWPVM6 Improve the condition of Black Box dominated EVCs
LTWP target	A positive trend in the condition score of Black Box 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 (2006) levels of Black Box (*Eucalyptus largiflorens*) to sustain communities and processes reliant of such communities at the Karadoc asset
2020 Targets:	A positive trend in the condition score of Black Box dominated EVC benchmarks at the Karadoc asset at 50% of sites over the 10-year period. OR By 2030, at stressed sites (see Wallace et al. 2020) at the Karadoc asset: 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 Black Box trees needs to be established to ensure TCI good is achievable - may need to rewrite target and adaptively manage this as condition improves.

Current objective	K8: Provide suitable foraging and roosting habitat for Microbats
Comments	Deleted

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