Karadoc (Inlet Creek) Environmental Water Management Plan

mallee catchment management authority

Department of Environment, Land, Water & Planning
State Government Victoria

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EXECUTIVE SUMMARY

Environmental Water Management Plans (EWMPs) have been developed for key sites in the Mallee region. The Mallee Waterway Strategy 2014-22 (Mallee CMA, 2014) identified 23 Waterway Management Units (WMU) from 216 targeted waterways in the Mallee. The interconnectedness and commonality of threats impacting on the waterway values were used to group the WMUs into planning units. This EWMP has been developed for the Karadoc WMU, hereafter referred to as Karadoc. The EWMP will help to guide future environmental watering activities for this area.

Karadoc is located approximately 25 km south-southeast of Mildura on the Murray River floodplain and covers 6,827 ha. Recently two areas within Karadoc 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. There are several wetlands at Karadoc, whose primary use is for irrigation drainage disposal, which provides an ongoing constraint to environmental watering outcomes at Karadoc.

Environmental values for Karadoc include a diverse range of water dependent flora and fauna species including a number of depleted and vulnerable water dependent ecological vegetation classes such as Lignum Swamp and Lignum Swampy Woodland. Karadoc has significant social values for the local community and the local indigenous community has strong connections to the area.

Another constraint on the ability to provide environmental watering at Karadoc is the impact of watering on salinity in the Murray River, through the mobilisation of terrestrial salt via both surface and groundwater pathways. A 2015 and 2016 assessment of proposed watering regimes for the site resulted in a reduced target area due to modelled salinity impacts above the Basin Salinity Management Strategy of 0.1EC at Morgan.

Taking into consideration the results from the salinity assessments, the target area for environmental watering events within Karadoc is Inlet creek, an area of approximately 66.85 hectares.

The long term management goal for Karadoc (Inlet Creek) is:

“To provide a water regime that will support fringing Lignum and Blackbox communities and provide seasonal habitat for native fish, frogs and waterbirds”.

To achieve this goal, ecological and hydrological objectives have been developed for Karadoc (Inlet Creek). These are:

- Support the health of mature Black Box along Inlet Creek
- Provide seasonal aquatic habitat that supports a diverse population of native fish and frogs
- Productive and healthy Lignum Swampy Woodland vegetation community
- Provide suitable feeding and breeding habitat for various waterbird guilds
- Maintain high levels of aquatic productivity

A minimum, optimal and maximum long-term watering regime has been developed to maintain and enhance the various ecological requirements of Inlet Creek, including surrounding Lignum Swampy woodland.

Optimal watering regime

Provide environmental water to the target area three years in every ten to a height of 37.9 m AHD in late winter. Allow ponding at this level for up to five months to maintain habitat created by the flooding of the Lignum communities. Allow a natural recession of water level to expose the littoral zone and mudflats for wading birds and grazing waterfowl. Drying periods between watering events will improve aquatic productivity.

The delivery of environmental water necessary for this watering regime will require the installation of infrastructure, outlined in this plan. The proposed infrastructure requires further investigation and design.

ACKNOWLEDGEMENTS

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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 (Inlet Creek).

The key purposes of the EWMP are to:

- Identify the long-term objectives and water requirements for Inlet Creek;
- Provide a medium for community consultation, including for the long-term objectives and water requirements of the creek;
- Inform the development of seasonal watering proposals and seasonal watering plans;
- Inform long-term watering plans that will be developed under Basin Plan requirements.

2 SITE OVERVIEW

2.1 Site Location

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

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

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

The site for this plan is the Karadoc FMU, hereafter referred to as Karadoc. Karadoc is a sub unit of the Karadoc WMU located between river km 923 and 952, 25km south-southeast of Mildura (Figure 1). Karadoc WMU covers a series of unconnected sub-units from Nangiloc to Kings Billabong.

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

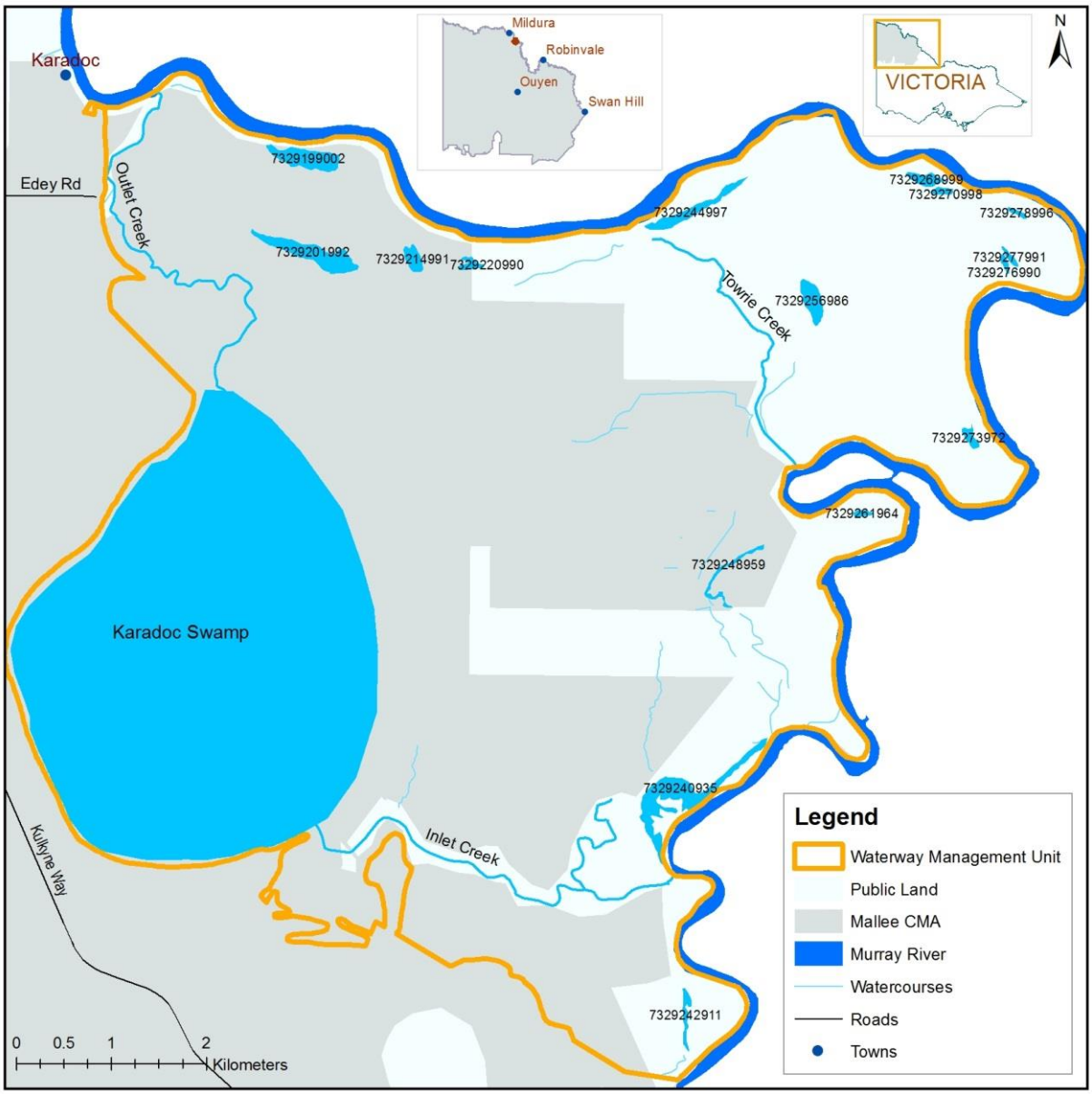


Figure 1. Location of wetlands and waterways at Karadoc

2.2 Catchment setting

Karadoc is situated 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. 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 (DEPI 2010).

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).

Surrounding land is mostly used for cropping or cleared for grazing with no buffer between Karadoc 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).

Land systems

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. In some instances, the Monoman Formation is difficult to distinguish from the Parilla Sand as it is lithologically similar; meaning that their physical characteristics visible at outcrop, in hand, core samples or with low magnification are similar.

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. In the study area its distribution and thickness is influenced by tectonic movements during and after the late Tertiary marine transgression. Through this, a series of structural troughs and ridges were formed resulting in thicker deposits of Blanchetown Clay being deposited in the troughs (Koorlong Trough and Karadoc Trough) whilst thinner sequences were deposited on the ridges (Red Cliffs Ridge and Merbein Ridge) (Thorne et al 1990).

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. The Lower Parilla Sands are identified by fine, well-sorted sands or silty-sands, and is marked by a colour change to dark grey in the Upper Parilla Sands. The Upper Parilla Sands are identified by their unconsolidated to weakly cemented, fine to coarse quartz sands. The Lower Parilla Clay along with the underlying Bookpurnong Beds forms the regional aquitard and underlies the Parilla Sand.

Incision of the Murray Trench caused the River system to flow through valleys eroding into Blanchtown Clays in the troughs and Parilla Sands on the ridges. Scout hole drilling data (AWE, 2009) indicates complete erosion of the Blanchetown Clays in the river trench, although it persists beneath Karadoc Swamp and the surrounding floodplain. Occurring across both the highland and floodplain the Parilla Sands underlie the Monoman Formation and form the regional aquifer.

2.3 Karadoc

Karadoc contains a series of 16 wetlands and three creeks including Karadoc Swamp, Inlet and Outlet Creeks and Towrie Creek.

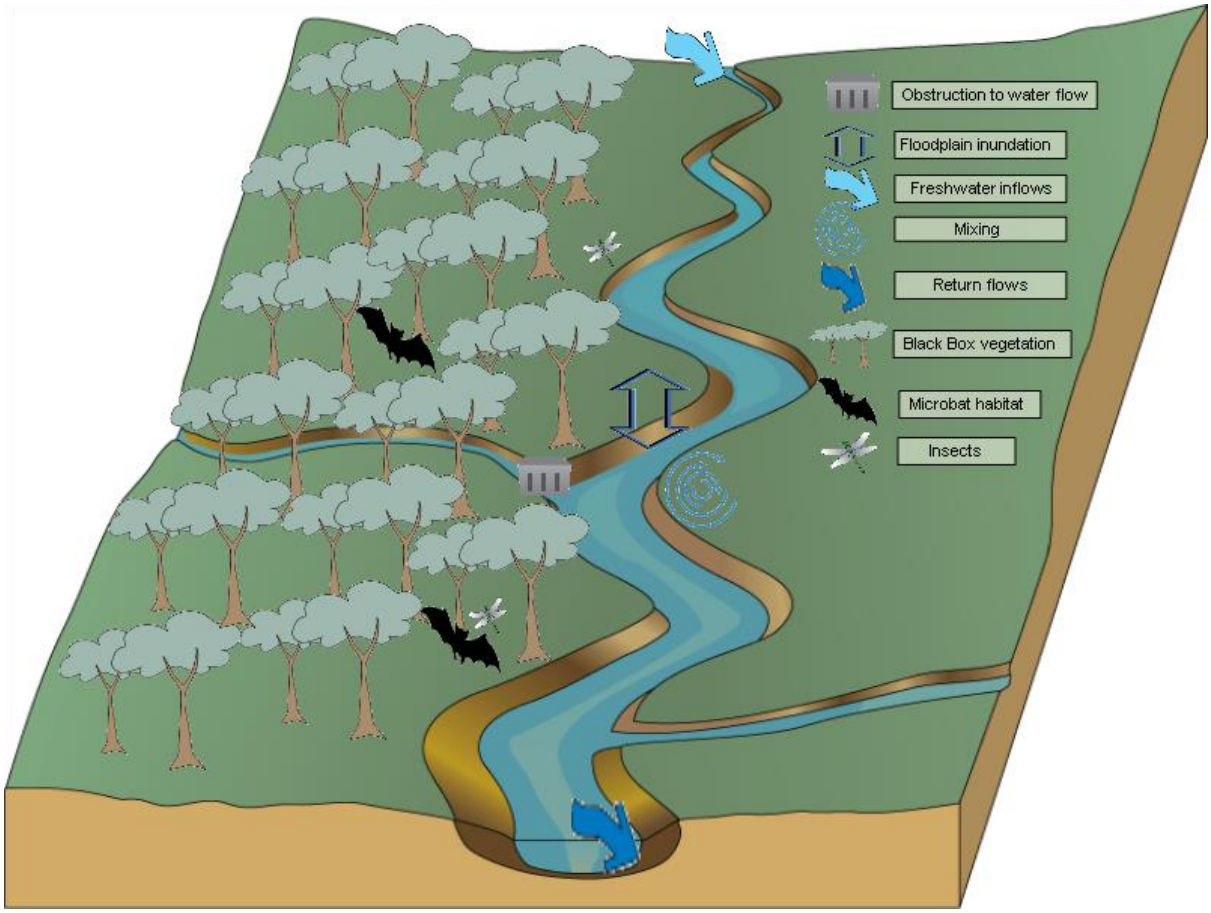
Karadoc Swamp is the largest wetland in the Mallee Waterway Strategy with an area of 6,827.28 ha (Ecological Associates 2007) and a maximum depth of 4m (SKM 2002). Karadoc Swamp is classified as semi-permanent saline and is considered to be an area of environmental and conservation value with flora and 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 salinisation 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). The Swamp Sheoak Action Statement (DSE, 2003) notes that increasing salinity levels at Karadoc Swamp will most likely lead to demise of that local population.

2.4 Conceptualisation of the Site

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

Inlet Creek and adjacent floodplain



High Murray River flows which inundate the waterways and floodplain are currently reduced by **obstructions to water flow** (manmade sills etc.)  . Environmental water will 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.

Figure 2. Conceptual model of the ecological processes, threats and values associated with proposed watering at Karadoc

2.6 Land status and management

Several agencies and individuals are involved in managing the land at Karadoc (Table 1). The public land within the Karadoc area has historically been managed by the Department of Environment, Land, Water and Planning (DELWP) as State Forest in the Murray River Reserve (Parks Victoria 2012). Karadoc 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). The remainder of the land at Karadoc is private land (Figure 3).

Table 1. Karadoc Environmental Water Management Stakeholders

Group	Role
Parks Victoria	Land Manager. Parks Victoria are responsible for "Conserving Victoria's Special Places" with the aim to ensure that our valued parks, and the natural assets and cultural heritage they hold, can be enjoyed now and by future generations.
Mallee Catchment Management Authority	Regional environmental and waterway management.
Department of Environment and Primary Industries	State level environmental water management planning, land manager, threatened species manager.
Goulburn Murray Water	Murray River operations.
Victorian Environmental Water Holder	Management of environmental water holdings.
Commonwealth Environmental Water Holder	Management of environmental water entitlements.
Aboriginal Communities	Indigenous Representation.
Private Landholders	Landholders.

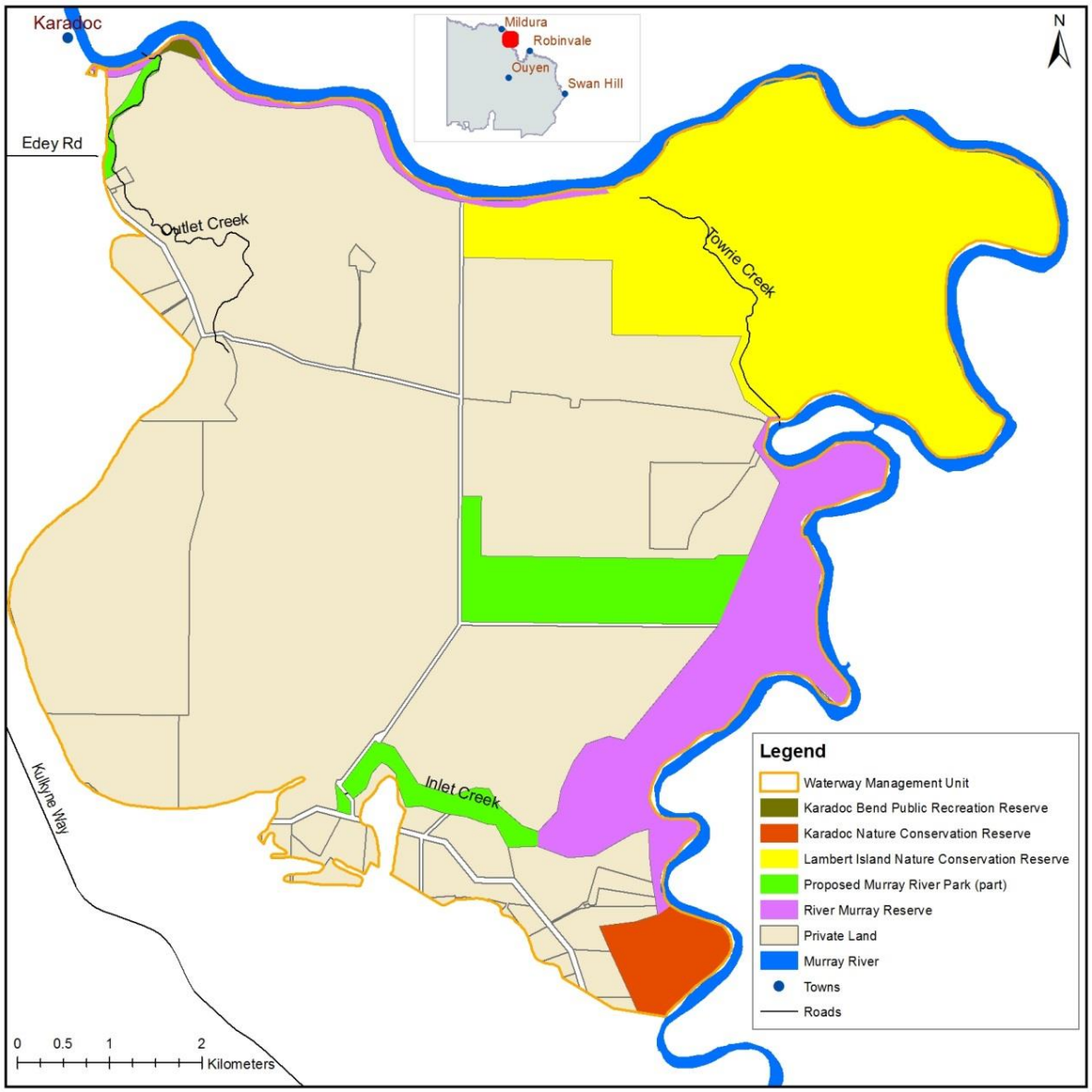


Figure 3. Land management boundaries at Karadoc

2.7 Wetland characteristics

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

Table 2. Wetland characteristics for Karadoc

Characteristics	Description
Name	Karadoc Waterway Management Unit Sub-unit
Individual wetlands within Karadoc WMU Sub-unit (numbers follow Corrick numbering system in Wetlands 1994 layer)	#7329 199002, #7329 201992, #7329 214991, #7329 220990, #7329 244997, #7329 256986, #7329 26899, #7329 270998, #7329 278996, #7329 277991, #7329 276990, #7329 273972, #7329 261964, #7329 248959, #7329 240935, #7329 242911 Karadoc Swamp Towrie Creek, Outlet Creek and Inlet Creek
Area	Total area 6,827ha Total wetlands 1,917ha
Bioregion	Robinvale Plains
Conservation status of EVCs at Karadoc	Vulnerable, Depleted and Least Concern
Land Status	Regional Park, Nature Conservation Reserve, Private Land
Land manager	Regional Park, Nature Conservation Reserve, Private Land
Surrounding land use	Agriculture
Water supply	From the Murray River - Outlet Creek, #7329 199002, #7329 201992 & #7329 214991(ctf @ 43,000 ML/d), Inlet Creek (ctf @ 52,000 ML/d).
1788 wetland category	Shallow freshwater marsh - #11398, #11400, #11425, #11426, #11421, #11419 Deep freshwater marsh - #11404, #11427 Freshwater meadow - #11407, #11417, #11429 Permanent open freshwater - #11413, #11416
1994 wetland category and sub-category	Deep Freshwater Marsh - #79329 214991, #7329278996, #7329273972 Freshwater Meadow - #7329220990, #7329277991, #7329276990, #7329244997 Permanent open freshwater - #7329240935, #7329242911 Shallow Freshwater Marsh - #7329199002, #7329201992, #732926899, #7329270998, #7329256986, #7329261964, #7329248959 Semi-permanent saline – Karadoc Swamp
2013 wetland category	All wetlands – Type unknown
Wetland depth at capacity	Unknown

2.9 Management Scale

The whole of Karadoc has a water requirement as a floodplain complex, but the focus of this EWMP is restricted to Inlet Creek, a target area of 66.85 ha, as shown in the maximum inundation extent in Figure 4. This is the area of Karadoc that is able to be managed with environmental water, following the construction of the infrastructure proposed in this EWMP and allowing for consideration of salinity risks associated with environmental watering.

The other wetlands and creeks at Karadoc have been excluded from the target area because they are either:

- close to the Murray River and are influenced by river flows;
- are higher on the floodplain and watering them would inundate lower lying non-target areas;
- watering would cause salinity impacts above the Basin Salinity Management 2030 target of 0.1EC at Morgan; or
- are not able to be watered with the current or proposed infrastructure.

Table 3 - Justification for exclusion of wetlands at Karadoc from the target area

Wetland	Reason for exclusion from the target area
#7329 199002	Unacceptable salinity impact
#7329 201992	Unacceptable salinity impact
#7329 214991	Unacceptable salinity impact
#7329 220990	Influenced by low river flows
#7329 244997	Influenced by low river flows
#7329 256986	Higher on the floodplain, risk of inundating non-target areas
#7329 268999	Influenced by low river flows
#7329 270998	Influenced by flow river flows
#7329 278996	Influenced by low river flows
#7329 277991	Influenced by low river flows
#7329 276990	Influenced by low river flows
#7329 273972	Influenced by low river flows
#7329 261964	Influenced by low river flows
#7329 248959	Unacceptable salinity impact
#7329 240935	Unacceptable salinity impact
#7329 242911	Influenced by low river flows
Karadoc Swamp	Unacceptable salinity impact
Towrie Creek	Influenced by low river flows
Outlet Creek	Unacceptable salinity impact

Karadoc Swamp has been excluded from the target area as this is an active drainage disposal basin and watering of the Swamp would result in an unacceptable salinity impact at Morgan.

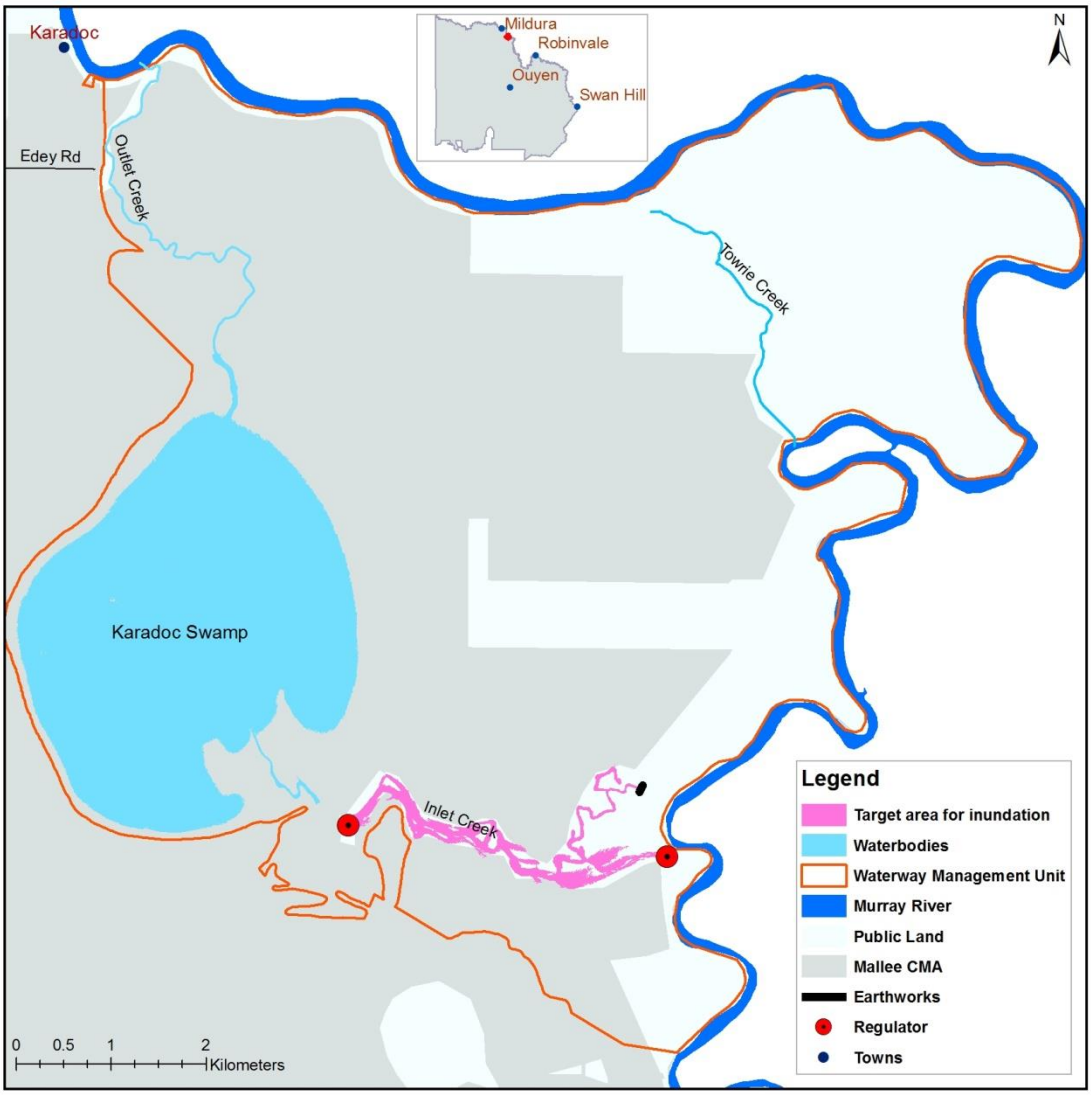


Figure 4. Target inundation area for Karadoc, consisting of the areas shown in the maximum inundation extent.

2.10 Assessment of Salinity Risk

The Murray-Darling Basin Ministerial Council released the Basin Salinity Management 2030 (BSM 2030) in 2015. This document builds on the Basin Salinity Management Strategy of 2001-2015 (BSMS) and provides a program of salinity management across governments to meet the Basin Salinity Target of maintaining the salinity at Morgan at less than 800 EC for 95 per cent of the time. An accountable action under this plan is one that is assessed as causing a change in average daily salinity at Morgan of 0.1 EC or more by 2100.

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

- Surface water
  - Mixing of existing surface water.
  - Salt wash-off from floodplain soils.
  - Evaporative concentration of impounded waters.
  - A release of surface water (and salt load) to the Murray River.
- Groundwater
  - Enhanced recharge to groundwater.
  - A rise in groundwater levels and an altered hydraulic gradient across the floodplain.
  - A resultant increase in groundwater flux (and salt load) to the Murray River.

The estimated potential EC impact at Morgan for the draft recommended watering options at Karadoc are presented in Table 4. The reportable impacts are highlighted in red, and all watering options proposed for this assessment had significant reportable impacts. Following the 2015 assessment, the proposed target area and watering regime for Karadoc was revised to limit watering to Inlet Creek and a re-assessment of salinity impact was undertaken (Currie and Richardson, 2016). Following the salinity re-assessment, the draft EWMP was updated to reflect the current target area which is Inlet Creek only. The salt mobilisation processes associated with the Inlet Creek watering option are all groundwater pathways, as no release of environmental water back to the Murray River is recommended within this option.

Table 4. Estimated potential EC impact at Morgan for proposed Karadoc watering options ((Richardson and Currie, 2015) and (Currie and Richardson, 2016))

Option	Watering regime	Estimated EC impact at Morgan		
		Groundwater pathway	Surface water pathway	Total
Outlet Creek	Min	0.28	n.a	0.29
	Opt & Max	0.58	n.a	0.58
Inlet Creek and Wetland #7329248959	Min	0.03	0.47	0.50
	Opt	0.04	0.71	0.75
	Max	0.07	1.18	1.25
Karadoc Swamp	Min	0.01	1.68	1.69
	Opt	0.01	2.52	2.53
	Max	0.02	4.19	4.21
Karadoc Swamp and Outlet Creek	Min	0.25	1.06	1.31
	Opt	0.37	1.59	1.96
	Max	0.62	2.65	3.26
Inlet Creek (revised option modelled in Currie and Richardson, 2016)	Min	0.001	n.a.	0.001
	Opt	0.061	n.a.	0.061
	Max	0.096	n.a.	0.096

2.11 Environmental Water Sources

The Environmental Water Reserve (EWR) is the legally recognised amount of water set aside to meet environmental needs. This 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 waterways to protect their environmental values and health.

Environmental Water for the study site may be sourced from the water entitlements and their agencies listed in Table 5 and further explained in the Regional Context Document for Environmental Water Management Plans (Sunraysia Environmental 2014). Other sources of water may become available through water trading or changes in water entitlements.

Table 5. Summary of environmental water sources available to Karadoc

Water Entitlement	Responsible Agency
Murray River Unregulated Flows	Murray Darling Basin Authority
Murray River Surplus Flows	
Victorian Murray River Flora and Fauna Bulk Entitlement	Victorian Environmental Water Holder
Commonwealth water	Commonwealth Environmental Water Holder
Donated Water	Victorian Environmental Water Holder

2.12 Related Agreements, Policy, Plans and Activities

There is a range of international treaties, conventions and initiatives, as well as National and State Acts, policies and strategies that direct management of Karadoc. Those with particular relevance to the site and the management of its environmental and cultural values are listed in Table 6. For the functions and major elements of each refer to the Regional Context Document (North, 2014).

Table 6. International conservation conventions, and national and state legislation relevant to management of the target area

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

Karadoc is situated on the Victorian floodplain of the Murray River which is the subject of investigation in many guises. These include Salinity Management Plans, Flow studies and Land Conservation Council (LCC) Reviews. An investigation into River Red Gum Health by the Victorian Environmental Assessment Council (VEAC) in 2008 resulted in changes in areas within Karadoc from State Park to Regional Park and Flora Reserves to Nature Conservation Reserves in 2010.

Mallee Waterway Strategy 2014 - 2022

The Mallee Waterway Strategy (Mallee CMA, 2014) sets regional goals for waterway management that align with the Mallee Regional Catchment Strategy's broader objectives, identifies high value waterways, details strategic work programs for priority waterways, identifies the roles and responsibilities of regional stakeholders and establishes principles to guide the implementation. Under this strategy Karadoc Swamp is listed as a medium priority wetland, Outlet Creek and Towrie Creeks are listed as high priority reaches and Inlet Creek is listed as a medium priority reach.

Mallee Catchment Management Authority Frontage Action Plan

Karadoc is within an area covered by the Mallee CMA Frontage Action Plan (FAP) (MCMA 2003) and has the potential to attract future funding and works through that project.

Other works

During 2006 – 2009 the Mallee CMA undertook some stock control fencing in consultation with the landholders along with some revegetation activities where Towrie Creek connects with the Murray River and where Outlet Creek joins Karadoc Swamp. Negotiations are currently underway with landholders for further stock control fencing in the south eastern section of Karadoc.

Regional Context Document for Environmental Water Management Plans

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

Nangiloc-Colignan Salinity Management Plan

The Nangiloc Colignan drainage scheme was implemented under the Nangiloc Colignan Salinity Management Plan and was designed to overcome waterlogging and salinity issues due to inadequate drainage disposal. A system of pipelines which collect subsurface drainage from irrigated properties was established, some of which discharge to the Murray River via Karadoc Swamp. The drainage water to the Swamp is typically between 1,000 and 2,500 EC. Continuous flow and salinity readings are recorded to ensure drainage from the Nangiloc-Colignan scheme have no more than 0.5 EC impact at Morgan (Thompson & Cummins 2012).

Karadoc Swamp Wetland Management Plan

In 2002 SKM developed a Karadoc Swamp Wetland Management Plan. The management plan set objectives for the wetland but was also based on LCC recommendations for the surrounding public land. These were:

1. Restoration of flora and fauna values, in particular the *Casuarina obesa* population, associated with the wetland.
2. Manage downstream water quality impacts – particularly salinity.
3. Protect and manage cultural sites.
4. Ensure a coordinated management approach with landholders adjacent to the wetland.
5. Gain agreement from all management parties to manage the wetland in an adaptive manner.
6. Promote a community understanding of the ecological processes associated with the wetland.

Investigation of Water Management Options for the River Murray – Robinvale to Wallpolla Island

In 2006, Mallee CMA engaged consultants Ecological Associates to investigate water management options for the floodplain of the Murray River from Robinvale to Wallpolla Island. This investigation identified management units (FMUs), identified ecological values, developed objectives, defined water regimes, identified threats, and proposed management actions and infrastructure to enable inundation.

Water Management Options for the Murray River – Robinvale to Wallpolla, Stage II

In 2007, Ecological Associates developed the Water Management Options for the Murray River – Robinvale to Wallpolla, Stage II for the Mallee CMA. This report costs designs for environmental watering infrastructure, proposes alternative water management options, documents environmental impacts and documents Cultural heritage values.

Basin Salinity Management 2030

As mentioned previously, the Murray-Darling Basin Ministerial Council released the Basin Salinity Management 2030 (BSM 2030) in 2015.

Schedule B of the Water Act (2007) requires that, if an activity; causes a significant salinity effect it be treated as an accountable action. Accountable actions trigger a detailed assessment and possible entry on either of the salinity Registers (A or B).

Salinity Impact Assessment for Mallee Environmental Watering Sites

A study was undertaken on Karadoc by Australian Water Environments (AWE) during 2014. The Mallee CMA provided AWE with the details of 5 proposed environmental watering regimes and were asked to provide a preliminary salinity impact assessment (Figure 5). This study was undertaken to identify if the proposed activity would have an impact on an area that is accountable under the BSMS. AWE identified key salt mobilisation processes that could be triggered by the proposed watering activities and salinity impacts through hydrogeological characteristics of the site.

Results confirmed that all five proposed regimes would produce in-stream salinity impacts required to be accounted for under the BSMS registers; with recommendations to undertake groundwater and salinity level monitoring during the program to assess leakage rates through vertical and horizontal conductivity of the Coonambidgal clay. This assessment resulted in a reduction in area for three of the options and a reconsideration of the duration of inundation for a further two.

3 HYDROLOGY AND SYSTEM OPERATIONS

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

The target area within the Karadoc Waterway Management Unit is located on the Victorian floodplain of the Murray River (chainage 923 km to 952 km) between river gauges Euston (# 414203C) and downstream Mildura Weir (# 414216A).

SKM (2013) described a real-time flood at Karadoc Swamp in 2010/11. 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.

3.1 Hydrogeology

Hydrostratigraphy

The major hydrostratigraphic units encountered within Karadoc, in order of increasing depth, are the Coonambidgal Formation, Channel Sands, Blanchetown Clay and Parilla Sands. The Coonambidgal Formation forms an aquitard at the top of the sedimentary sequence within the Murray River trench and semi-confines the underlying Channel Sands floodplain aquifer. Bore log data suggests that the Blanchetown Clay is present beneath Karadoc Swamp and the outer edges of the floodplain which provides separation between the Channel Sands and Parilla Sands aquifers. Where the Blanchetown Clay is absent, the Channel Sands and underlying Parilla behave as a single regional aquifer.

The extent and thickness of both the Coonambidgal Formation and Blanchetown Clay are likely to be key controls on the interaction between Karadoc Swamp and the underlying groundwater system and the therefore influence the magnitude of potential salinity impacts from floodplain watering (Richardson and Currie, 2015).

Groundwater levels and flow

Groundwater level contours reflect groundwater flow towards the Murray River (Richardson and Currie, 2015). Groundwater level hydrographs for the Channel Sands aquifer indicate a declining trend in groundwater levels over the past 15 years, although data is limited (Richardson and Currie, 2015). Hydrograph data for the Parilla and Channel Sands aquifers by (Australian Water Environments, 2014) indicate downwards vertical groundwater gradients under the irrigation areas and western floodplain, consistent with irrigation recharge to the groundwater system. Near the Murray River to the east and north of the floodplain, the vertical gradients are upward, consistent with groundwater discharge to the Murray River (Richardson and Currie, 2015).

Groundwater salinity

Groundwater salinity is variable across the floodplain and data indicates salinities between <15,000 and 60,000 EC in the Channel Sands and typically around 40,000 EC (Richardson and Currie, 2015). An AEM survey undertaken in 2007 (Australian Water Environments, 2014) indicates the presence of high salinity groundwater under the majority of the Karadoc Swamp floodplain. Low salinities have been observed closer to the Murray River on Lambert Island and further downstream which may indicate loosing stream conditions (Richardson and Currie, 2015). Low salinity drainage water may also be assisting lower salinity conditions on the western perimeter of Karadoc Swamp as well as within the Swamp (Richardson and Currie, 2015).

Surface water-groundwater interactions

As mentioned previously, groundwater level contours indicate predominately gaining river conditions, particularly near the Murray River junctions with Outlet and Inlet Creeks. Karadoc Swamp is connected to the groundwater system and may receive discharge when surface water is low, but it is likely that the gradient will reverse when the Swamp is filled (Richardson and Currie, 2015).

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 salinised (SKM 2002).

Linke (1990, cited in SKM 2002) estimated groundwater discharge to Karadoc Swamp to be 325 ML/yr. 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)

3.2 Water management and delivery

Pre-regulation

Under natural conditions, flow is understood to have been strongly seasonal, with median daily discharge highest in late winter to spring and lowest in autumn (SKM, 2002). Prior to river regulation, floodplain inundation would have occurred more frequently than under current regulated conditions.

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).

Post-regulation

Under post-regulation conditions Karadoc Swamp receives inflows from the Channel Sands aquifer, the perched watertable, 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).

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).

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). 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 5).

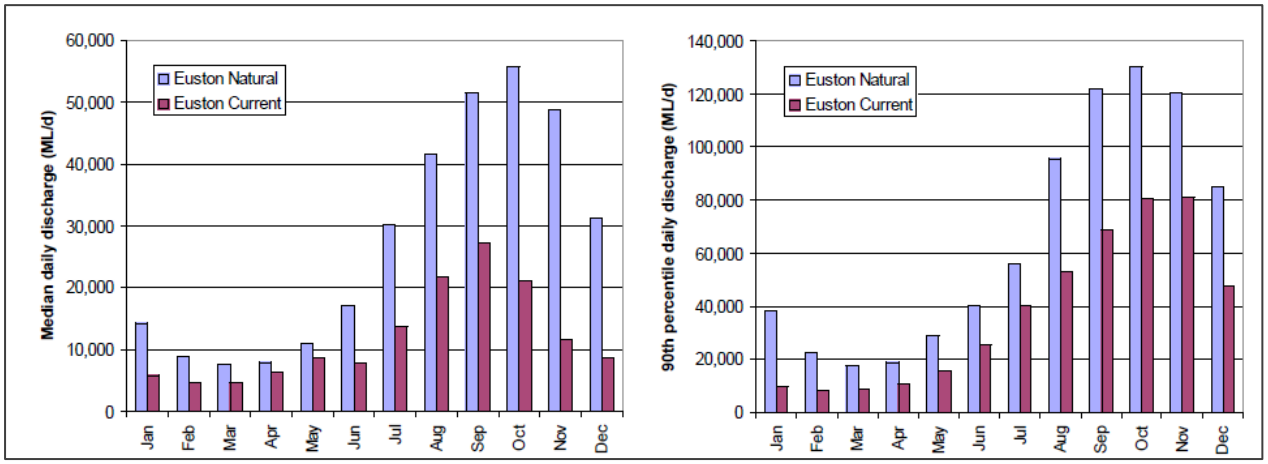


Figure 5. Distribution of median flows and 90th percentile flows for each month in the Murray River through Euston Weir for natural and current (benchmark) conditions

Spells analysis undertaken (Gippel 2014) was consulted to model flow downstream of Euston (Figure 6). The commence to flow threshold of 60,000 ML/day for Inlet Creek is presented in Table 7. The spells analysis shows that flows that would inundate Inlet Creek have reduced by approximately 50% in the frequency and duration, and an average 57% increase in intervals between inundation events.

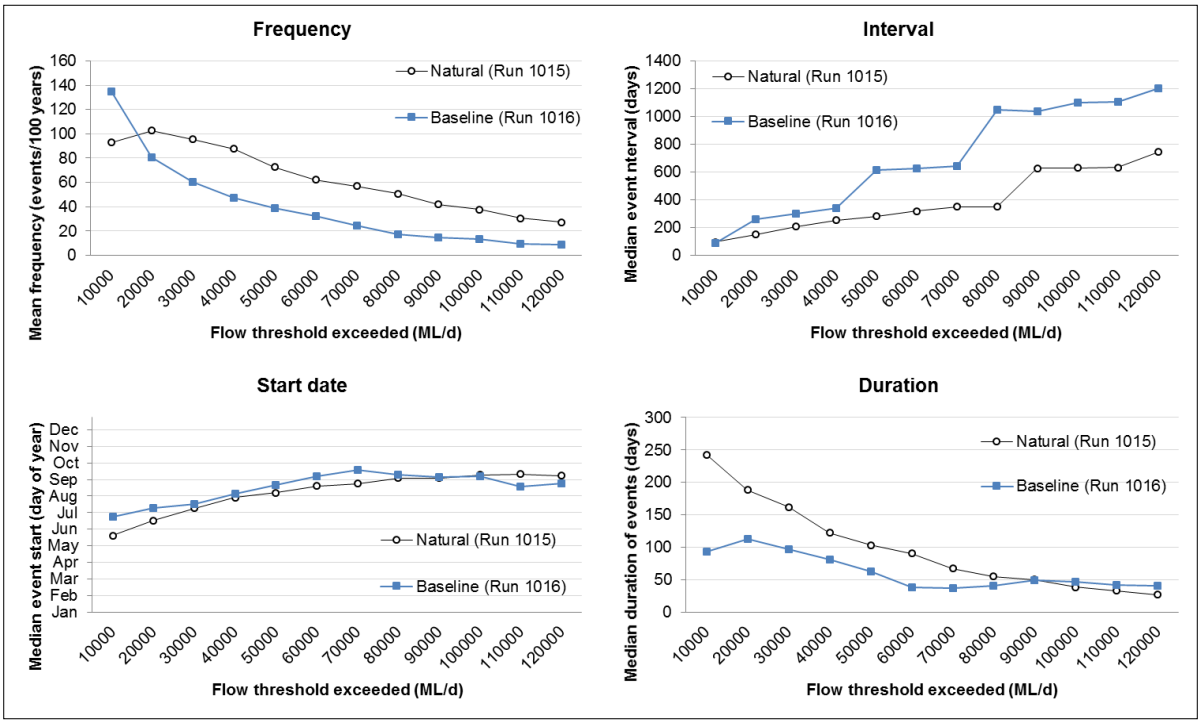


Figure 6. Comparison of Natural and Baseline Modelled Flow Scenarios for Euston Downstream (Gippel, 2014)

Table 7. Modelled natural and baseline flows for the commence to flow for Inlet Creek of 60,000 ML/d (Gippel, 2014)

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	60,000	6.23	319	91	25th Aug	63%
B	60,000	3.25	624	38	12th Sept	30%

High flows, except for the extreme floods, have been affected which reduces the flooding of anabranches and floodplain habitats. A reduction in the frequency of inundation of these habitats was identified as a key threatening process in this reach by the Murray River Scientific Panel which was commissioned by the then Murray Darling Basin Commission (Thoms et al 2000). Extreme low flow events have been removed, due to the requirement of minimum flows for irrigation and interstate agreements (SKM 2002).

Previous Environmental watering

Environmental water was delivered to Karadoc for the first time during 2014. This watering event delivered approximately 400 ML of water to Outlet Creek, watering a total area of 1357.4 hectares from 15th May 2014 to 13th June 2014. 200 ML was allocated by the Commonwealth Environmental Water Holder and 200 ML from the Victorian Environmental Water Holder.

The aim of this watering event was to reduce the accumulated salt load in Karadoc 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. Although it is too early to measure the environmental benefits provided by this watering event, anecdotal evidence suggests epicormic growth of River Red Gum and increased visitation to the inundated areas by waterbirds, particularly ducks.

Inlet Creek has not received environmental water to date.

4 WATER DEPENDENT VALUES

4.1 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.

As survey records for Inlet Creek are limited, this section describes flora and fauna found across Karadoc, which is likely to occur within the Inlet Creek target area.

Listings and significance

Fauna

Karadoc provides habitat for a large range of fauna. Native species recorded at Karadoc are listed in Appendix 1. This list includes a range of water dependent species which will benefit from 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 8.

Table 8. Listed fauna recorded at Karadoc

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

Legend

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

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

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

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

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

The species listed in Table 8 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. In order 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 CreekThese 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). . It is likely that Inlet Creek could support these species with an appropriate watering regime in place. 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 1), some of which are listed in various Acts and Conventions Table 8. 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 uses and food requirements of the waterbird guilds likely to be supported in the target area are recorded in Table 9.

Table 9. 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

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.

Vegetation communities

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, Land, Water and Planning (DELWP) has defined all of the EVCs within Victoria.

Within the target area, the most extensive EVCs are Lignum Swampy Woodland and Riverine Chenopod Woodland, with smaller areas of Shrubby Riverine Woodland and Semi-arid Chenopod Woodland.

For a full list of EVCs within the entire area and details on each see Appendix 2. The water dependant EVCs within the target area and their conservation status can be seen in Table 10 and Figure 7.

Table 10. Conservation status of water dependent EVCs in the target area

EVC no.	EVC name	Bioregional Conservation Status Robinvale Plains Bioregion	EVC Area (ha)
	Lignum Shrubland	Least Concern	0.75
823	Lignum Swampy Woodland	Depleted	48.90
103	Riverine Chenopod Woodland	Depleted	14.40
818	Shrubby Riverine Woodland	Least Concern	2.80
98	Semi-arid Chenopod Woodland	Vulnerable	0.01

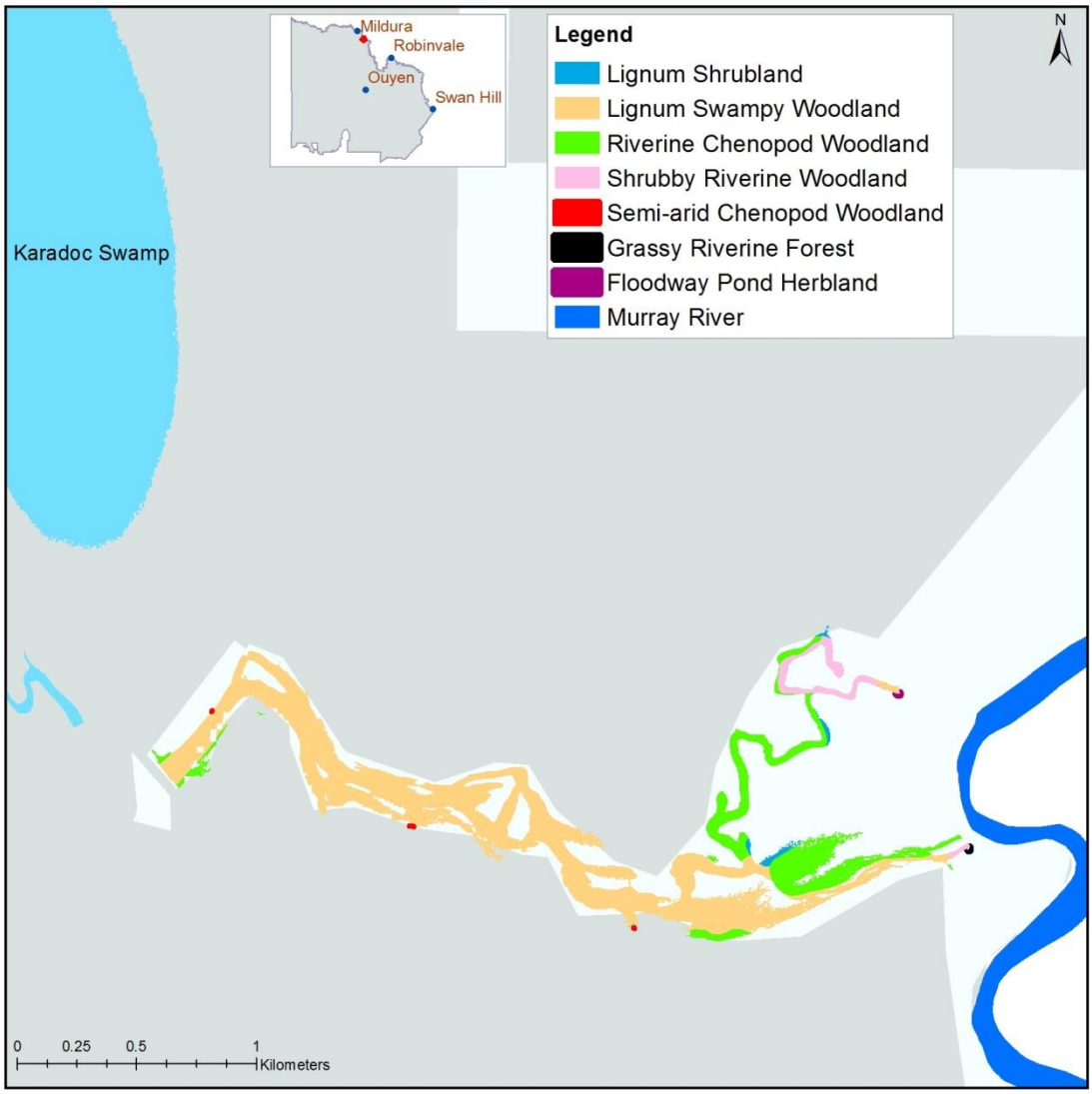


Figure 7. Water dependant EVCs within the target area of Karadoc

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. 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 Swampy Woodland would have experienced a flooding event in 1 in 2-8 years under natural conditions, with a critical interval of 15 years between events. The duration of ponding required for healthy Lignum Swampy Woodland is 2-4 months (VEAC 2008).

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). 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).

River Red Gums (*Eucalyptus camaldulensis*) are an overstorey component of Lignum Swampy Woodland and Shrubby Riverine Woodland. 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).

Flora

A recent search of the DELWP Advisory List of Rare or Threatened plants recorded at Karadoc can be found in Appendix 1. Water dependent flora species listed in the various acts and agreements which have been recorded at Karadoc are listed in Table 11.

Table 11. Listed water dependent flora species recorded at the site

Common name	Scientific name	FFG Act	DELWP listing
Spreading Emu-bush	*Eremophila divaricata* subsp. *divaricata*		R
Woolly Minuria	*Minuria denticulata*		R
Dwarf Amaranth	*Amaranthus macrocarpus* var. *macrocarpus*		V
Coral Saltbush	*Atriplex papillata*		R
Small Water-fire	*Bergia trimera*		V
Swamp Sheoak	*Casuarina obesa*	L	EN
Cane Grass	*Eragrostis australasica*		V
Purple Love-grass	*Eragrostis lacunaria*		V
Bristly Love-grass	*Eragrostis setifolia*		V
Native Peppercress	*Lepidium pseudohyssopifolium*		PK
Tough Scurf-pea	*Cullen tenax*	L	EN
Yellow Tails	*Ptilotus nobilis* var. *nobilis*		EN
Yakka Grass	*Sporobolus caroli*		R
Spiny-fruit Saltbush	*Atriplex spinibractea*		EN
Kneed Swainson-pea	*Swainsona reticulata*	L	V

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

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

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

Ecosystem functions

Creek and floodplain ecosystems support distinctive communities of plants and animals and provide numerous ecosystem services to the community (DEPI 2005). Ephemeral creeks 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;
- 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.

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

Drying of the littoral zone, 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 allows exposure of substrates such as large wood and plant stems through a drying cycle, which increases the diversity of the biofilms grazed by macroinvertebrates and fish. Seasonal fluctuations in water levels also increases the availability of specific habitat niches for feeding, breeding and nursery areas.

Creek inundation and recession increases the extent of the band of sedges, rushes and semi-aquatic forbs surrounding wetlands. When inundated, areas of deeper water in Inlet Creek support submerged aquatic macrophytes and provide high levels of aquatic productivity and habitat value for frogs, fish, and diving ducks. Shallow water and aquatic macrophytes along the fringes of the creek will support dabbling and grazing ducks. The littoral zone will provide foraging habitat for wader birds as well as dabbling and grazing ducks and habitat for frogs. Fish within the creek will be a food source for piscivorous birds.

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.

4.2 Social

Cultural Value

The cultural heritage value is described for the Karadoc WMU, which incorporates the Inlet Creek target area.

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

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

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

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

Cultural heritage

The Karadoc Swamp and surrounding floodplain 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 regard to 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.

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.

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. There is no native title claim over this area but the Latji Latji and Nyeri Nyeri people have a vested interest in this region.

European heritage reflects the pioneering history of the area. Significant European footprints including Canadians George and William Chaffey came to develop irrigation infrastructure on an old sheep station arising in the settlement of Mildura in 1887.

Recreation

The region is popular for swimming, camping, fishing 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.

4.3 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.

4.4 Significance

The environmental, social and economic values outlined indicate the significance of this site. While these values do not constitute Karadoc being a unique or pristine site, the riparian and floodplain communities of the Murray River are important to the functioning of the river system and its sustainability. The 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, 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 Lignum Swampy Woodland (depleted) EVC that dominates the target area provides essential habitat for a diverse range of fauna, particularly waterbirds. The site also has provide habitat for 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 microbat species.

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

5 ECOLOGICAL CONDITION AND THREATS

5.1 Current condition

An Index of Stream Condition (ISC) assessment undertaken in 2010 showed that Inlet Creek (reach length 6.1 km) was in poor condition (Table 12).

Table 12. Index of Stream Condition scores (2010)

Sub-index	Measure	Score
Streamside zone	Vegetation Width	3/5
	Fragmentation	2/5
	Vegetation Overhang	2/6
	Large Trees	Not assessed
	Tree Cover	4/5
	Shrub Cover	4/5
	Structure	3/5
	Weeds	5/5
	Total score	**6**
Physical Form	Artificial Barriers	2/5
	In-stream Large Wood	3/5
	Bank Condition	5/5
	Total score	**7**
Hydrology	High flow	3/10
	Low flow	10/10
	Zero flow	10/10
	Seasonality	7/10
	Variability	10/10
	Total score	**2**

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. Figure 8 shows the dieback of mature Eucalypts along the creek line, as well as the presence of abundant woody debris. Figure 9 shows healthy Black Box and shrubs lining the channel.

Figure 8. Condition photo of Inlet Creek (ISC 2004) showing dieback of mature Eucalypts and abundant woody debris

Figure 9. Condition photo of Inlet Creek (ISC 2004) showing mature Black Box and shrubs lining the creek channel

5.2 Condition trajectory

Without management intervention in the form of environmental watering, the condition of water dependent ecosystems and species within the target area is expected to worsen. Dry conditions and salinity will continue to impact already severely stressed vegetation, including key species like 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.

5.3 Water related threats

Water dependent values for the target area are described in section 4. Threats to these values are the result of such factors as human intervention and climate variability. Some of the threats which impact on Inlet Creek include:

- Changed water regime;
- Loss or reduction of wetland connectivity;
- Water quality;
- Introduction/increase of exotic flora and fauna; and
- Salinisation

The regulation of the Murray River has seen the water regime through the Karadoc section of the Murray River floodplain altered. Flow events of the magnitude required enabling flows into Inlet creek and connecting wetlands of the floodplain are less frequent and of shorter duration. 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.

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. Salt tolerant species such as Glasswort and Saltbush sp. have succeeded where overstorey species have died out.

Introduced fish species Common Carp (*Cyprinus carpio*) and Mosquito fish (*Gambusia holbrooki*) pose a serious threat to the ecology of Inlet Creek. Ho et al (2004) found both these species to be present during aquatic vertebrate surveys within the nearby Towrie Creek and it is likely that they would inhabit Inlet Creek when inundated. Carp have been found to contribute to the loss of aquatic vegetation and increased turbidity, resulting in loss of habitat for waterfowl (Purdey & 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).

As indicated earlier, Predebon (1990) and the more recent Index of Stream Condition assessments have shown the impacts of salinisation in Inlet Creek.

7 MANAGEMENT OBJECTIVE

7.1 Management goal

The management goal for Karadoc (Inlet Creek) is:

"To provide a water regime that will support fringing Lignum and Blackbox communities and provide seasonal habitat for native fish, frogs and waterbirds".

7.2 Ecological Objectives

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

The ecological objectives for Karadoc (Inlet creek) are:

- Support the health of mature Black Box along Inlet Creek
- Provide seasonal aquatic habitat that supports a diverse population of native fish and frogs
- Productive and healthy Lignum Swampy Woodland vegetation community
- Provide suitable feeding and breeding habitat for various waterbird guilds
- Maintain high levels of aquatic productivity

Table 11. Justification of ecological objectives for the target area

Ecological Objective	Justification (value-based)
Support the health of mature Black Box along Inlet Creek	Black Box communities have suffered from lack of water within Karadoc. In a healthy state these flora species provide important habitat and feeding opportunities for listed species found in the target area, particularly hollow-dependent species such as Regent Parrot and microbat species.
Provide seasonal aquatic habitat that supports a diverse population of native fish and frogs	Frogs and small native fish, such as Gudgeon, will visit Inlet Creek when flooded and may breed. In turn, these fish will be an important food source for some birds and turtles.
Productive and healthy Lignum Swampy Woodland vegetation community	Inundation of Lignum woodlands will allow colonisation by native fish including Gudgeon and Murray-Darling Rainbowfish. Shelter and feeding habitat for frogs will also expand from the fringing wetland areas to the refuge of the deeper wetland areas. Healthy Lignum can also provide shelter and feeding sites for Carpet Python and Woodland birds such as Brown Tree-creeper.
Provide suitable feeding and breeding habitat for various waterbird guilds	Australia's waterbirds are often nomadic, requiring habitat patches throughout the landscape to facilitate movement. Providing areas of shallow water, deep water, mudflats and reeds at the wetland edge (littoral zone) will provide ideal feeding grounds for the various waterbird guilds recorded in the area, particularly as water levels fluctuate, increasing productivity along the wetland margin.
Maintain high levels of aquatic productivity	Alternating periods of inundation and exposure accelerate the decomposition of organic matter and increase availability for organic carbon and mineral nutrients in the wetland food web.

As more is learnt about the area and the response to the watering events are monitored, the principles of adaptive management along with availability of environmental water sources will guide future requirements and management actions at this and other environmental watering sites.

7.3 Hydrological Objectives

Hydrological objectives describe the components of the water regime required to achieve the ecological objectives for the target area. The hydrological requirements to achieve each of the ecological objectives are presented in Table 13 and are briefly described below.

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

Lignum can tolerate a wide range of wet and dry conditions as well as moderate salinity levels. Frequencies of one to three years are needed to maintain large shrubs with vigorous canopy while flooding every three to five years for maintenance of healthy shrubs. Intervals of seven to ten years can be tolerated by small shrubs but these are not suitable as nesting platforms. Durations of three to seven months sustain vigorous canopy, but waterlogging is detrimental. Although the timing of flooding is not crucial for Lignum, following natural seasonality is encouraged to provide for understorey and wetland plants (Roberts and Marston, 2000).

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

Table 13 - Hydrological objectives for Karadoc

Ecological Objective	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
	Min	Opt	Max	Min	Max	Min	Opt	Max		
Support the health of mature Black Box along Inlet Creek	2	3	3	3	10	2	4	6	Late winter/early spring	37.9
Provide seasonal aquatic habitat that supports a diverse population of native fish and frogs*										
Productive and healthy Lignum Swampy Woodland vegetation community	3	5	10	1	7	3	5	7	Late winter/early spring	37.9
Provide suitable feeding habitat for various waterbird guilds*	Variability in water level									Variability in levels
Maintain high levels of aquatic productivity										Drying of Inlet Creek between events

* Hydrological requirements met by other ecological objectives

7.4 Watering regime

The Inlet Creek 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.

Minimum watering regime

Provide environmental water to the target area two years in every ten to a height of 37.9 m AHD in late winter. Allow a gradual drawdown to expose the littoral zone and mudflats for wading birds, grazing waterfowl and shoreline foragers. Drying periods between watering events will improve aquatic productivity.

Optimal watering regime

Provide environmental water to the target area three years in every ten to a height of 37.9 m AHD in late winter. Allow ponding at this level for up to five months to maintain habitat created by the flooding of the Lignum communities. Allow a natural recession of water level to expose the littoral zone and mudflats for wading birds and grazing waterfowl. Drying periods between watering events will improve aquatic productivity.

Maximum watering regime

Provide environmental water to the target area three years in every ten to a height of 37.9 m AHD in late winter. Ensure flooding of the Lignum communities for seven months and then allow a natural recession of water level to expose a variety of habitat types. Drying periods between watering events will improve aquatic productivity.

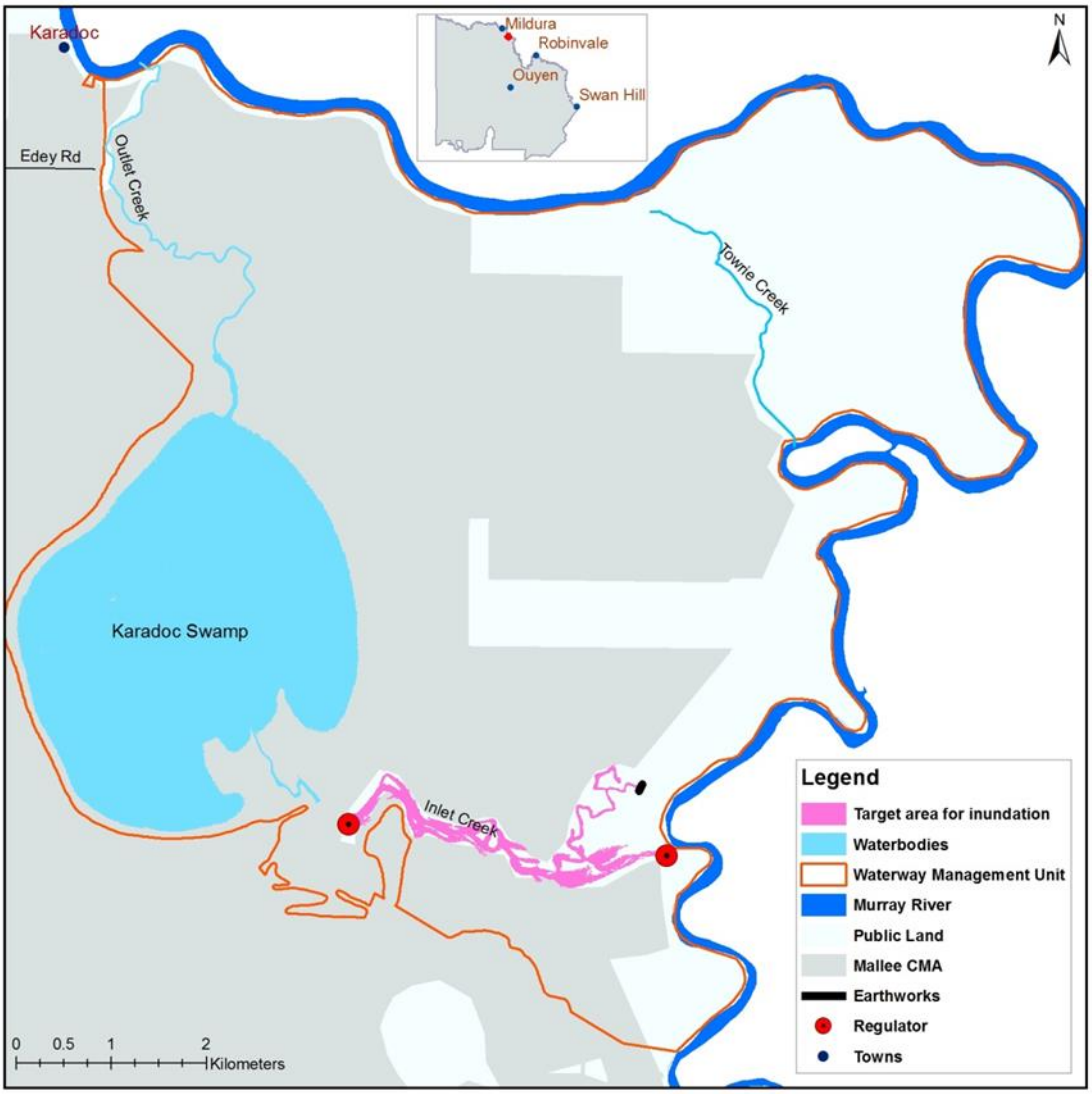


Figure 10. Inlet Creek inundation extent

8 MANAGING RISKS TO ACHIEVE OBJECTIVES

Table 14 below identifies the risks to the ecological objectives and watering requirements of the target area by identifying threats. Risks are classified as high, medium, or low dependent on the likelihood and consequence of them occurring.

Prior to delivering environmental water in any given season, these risks will be further refined as part of the Seasonal Watering Proposal and Environmental Water Delivery Plan process. These documents will provide a greater level of risk analysis and mitigation measures according to conditions observes closer to the proposed delivery (i.e. operational risks). The documents will also include detailed consideration of the impact of proposed mitigation measures on the likelihood and consequence of the risk occurring (residual risk) as this may change according to catchment conditions and operations closer to the proposed delivery. They will clearly outline roles and responsibilities regarding risk management.

Table 14. Table of risks associated with the proposed environmental watering

Threat	Likelihood	Consequence	Risk – H, M, L (likelihood x consequence)	Management Measure	Residual Risk
Salinity Impact at Morgan is >0.1EC	Unlikely	Moderate - Accountable Action required	Low	Salinity risk assessments have been undertaken for the watering regime and show impacts below the threshold of accountable actions under the BSMS (0.1EC at Morgan). Collection of salinity monitoring data during watering will help refine modelled estimates of salinity impact and potentially allow watering frequency to be increased.	Low
Flood duration too long or too short	Possible	Moderate - Water regime does not support breeding and feeding requirements of fauna or vegetation establishment and growth	Medium	Determination of water requirements to support potential breeding events through monitoring	Medium
Inability to provide optimal water regime to the target area	Possible	Moderate - Failure to achieve hydrological and ecological objectives for the site	Medium	Monitor flood duration to inform water delivery	Low
Flooding of surrounding private land	Unlikely	Moderate	Low	Add or drawdown water where appropriate or practical through monitoring of heights during filling.	Low
Increased recruitment and dispersal of alien fish	Likely	Major - Decreased public support for future environmental watering actions	High	Monitor the response of the wetlands to flooding. Install a carp screen Implement an appropriate drying regime.	Medium
Growth and establishment of aquatic pest plants – particularly Cumbungi	Possible	Moderate - Reduced habitat quality and increased competition for native aquatic plant species	Medium	Review and adjust the recommended optimal water regime	Low

9 ENVIRONMENTAL WATER DELIVERY INFRASTRUCTURE

9.1 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 a regulator would increase the extent of inundation to the whole target area and prevent this breakout.

9.2 Infrastructure recommendations

Infrastructure works are required to facilitate the delivery and ability to hold environmental water in the target area of Karadoc.

Table 15. Proposed infrastructure for watering at Karadoc

Proposed Infrastructure	Location	Purpose
New regulator	Where Inlet Creek connects to the Murray River (951 river km)	Allows no water to enter Karadoc Swamp, can also be utilised if Karadoc Swamp is to be watered in the future. The proposed infrastructure would give greater control of the water levels on the floodplain.

10 DEMONSTRATING OUTCOMES

10.1 Monitoring priorities at the site

Table 16. Recommended monitoring

Objective	Method	Priority
Measure the success of environmental water in improving wetland and riparian vegetation communities	Photo point monitoring	Medium
Monitor the salinity of groundwater and undertake salinity level monitoring during watering to assess leakage rates through vertical and horizontal conductivity of the Coonambidgal clay	Bore and surface water quality testing	High
Measure the success of watering against ecological objectives.	Waterbirds, fish, frogs	High
Benchmark and continued monitoring of stream condition	Index of stream condition	Medium
Accurate measurements of creek heights	Depth gauge monitoring	Medium

11 CONSULTATION

This plan was developed in collaboration with key stakeholders namely Parks Victoria, DELWP, local interest groups, and nearby residents (Table 20). Parts of Karadoc are freehold and consultation with local landholders was required regarding the management of all wetlands and associated waterways.

Table 17. Consultation process for development of Karadoc EWMP

Meeting date	Stakeholders	Details
2006 – 2009	Landholders	Consultation regarding revegetation and stock control fencing
2014	Parks Victoria	Initial discussion to introduce concept of plan
2014	Department of Environmental, Land, Water and Planning	Consultation on environmental management and project development
2014 - 2015	Landholders	Consultation regarding: • Pest, plant & animal control • Vegetation protection & conservation • Water Deed Agreements • Rubbish removal from waterways • Water quality assessment post flood events • Maintenance and rehabilitation on drainage lines and channels
2015	Landholders	Consultation regarding environmental watering proposals
TBA	Indigenous groups	Face to face discussions\on-Country visits
TBA	Local residents and landholders	Informal gathering to discuss environmental watering plan and signing of deeds
February 2015	Mallee CMA – Land and Water Advisory Group (Waterway health specialists)	Discuss ecological objectives and proposed environmental watering actions
02 March 2015	Aboriginal Reference Group	Discuss proposed environmental watering actions and direct engagement strategies with Traditional Owners

12 KNOWLEDGE GAPS AND RECOMMENDATIONS

This plan is based on best information at the time of writing. 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 18. A cultural heritage management plan would be essential before any on ground works could be undertaken.

Table 18. Knowledge gaps and recommendations for the target area

Knowledge and data gaps	Action recommended	Responsibility
Impacts of nearby irrigation on creek 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 creek	Data collection and monitoring	
Role of Inlet Creek in waterbird breeding and populations	Data collection and monitoring	
Role of Inlet Creek in fish breeding and population	Monitoring of fish population	
Accurate depth and volumes for the creek	Install depth gauges and bathymetric survey	
Bat population in the area	Monitoring and trapping program	
Current fauna and flora populations	Surveys, data collection and monitoring	

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14 ABBREVIATIONS AND ACRONYMS

CAMBA	China-Australia Migratory Bird Agreement
CMAs	Catchment Management Authorities
DEH	Department of Environment and Heritage
DEPI	Department of Environment and Primary Industries
EVC	Ecological Vegetation Class
EPBC Act	Environment Protection and Biodiversity Conservation Act
EWMP	Environmental Water Management Plan
EWH	Environmental Water Holder
FSL	Full Supply Level
G-MW	Goulburn-Murray Water
JAMBA	Japan-Australia Migratory Bird Agreement
MDBA	Murray-Darling Basin Authority (formally Murray-Darling Basin Commission, MDBC)
Ramsar	Global treaty adopted in the Iranian city of Ramsar in 1971 that focuses on the conservation of internationally important wetlands
ROKAMBA	Republic of Korea-Australia Migratory Bird Agreement
RRG	River Red Gum
RSWL	Reduced Standing Water Level
TLM	The Living Murray Initiative
TSL	Targeted Supply Level
VEWH	Victorian Environmental Water Holder

APPENDIX 1 FLORA AND FAUNA SPECIES LIST

Flora – Native

Common Name	Scientific Name	Records
Spreading Emu-bush	*Eremophila divaricata* subsp. *divaricata*	2
Black Cotton-bush	*Maireana decalvans* s.l.	2
Woolly Minuria	*Minuria denticulata*	1
Eumong	*Acacia stenophylla*	9
Flannel Cudweed	*Actinobole uliginosum*	3
Common Blown-grass	*Lachnagrostis filiformis* s.l.	3
Dwarf Amaranth	*Amaranthus macrocarpus* var. *macrocarpus*	1
Sand Wire-grass	*Aristida contorta*	1
Corky Saltbush	*Atriplex lindleyi* subsp. *inflata*	11
Slender-fruit Saltbush	*Atriplex leptocarpa*	19
Flat-top Saltbush	*Atriplex lindleyi*	36
Coral Saltbush	*Atriplex papillata*	10
Berry Saltbush	*Atriplex semibaccata*	13
Kidney Saltbush	*Atriplex stipitata*	3
Babbagia	*Osteocarpum acropterum* var. *deminutum*	2
Small Water-fire	*Bergia trimera*	1
Salt Club-sedge	*Bolboschoenus caldwellii*	2
Variable Daisy	*Brachyscome ciliaris*	5
Hard-head Daisy	*Brachyscome lineariloba*	10
Leek Lily	*Bulbine semibarbata*	9
Small Purslane	*Calandrinia eremaea*	21
Pale Beauty-heads	*Calocephalus sonderi*	1
Hairy Burr-daisy	*Calotis hispidula*	10
Inland Pigface	*Carpobrotus modestus*	2
Swamp Sheoak	*Casuarina obesa*	13
Flat Spurge	*Euphorbia drummondii*	9
Crested Goosefoot	*Dysphania cristata*	1
Cottony Saltbush	*Chenopodium curvispicatum*	1
Nitre Goosefoot	*Chenopodium nitrariaceum*	3
Dense Crassula	*Crassula colorata*	29
Sieber Crassula	*Crassula sieberiana* s.l.	22
Rosinweed	*Cressa australis*	11
Bear's-ear	*Cymbonotus lawsonianus*	2
Couch	*Cynodon dactylon*	5
Australian Hound's-tongue	*Cynoglossum australe*	1
Spiny Flat-sedge	*Cyperus gymnocaulos*	1
Rounded Noon-flower	*Disphyma crassifolium* subsp. *clavellatum*	5
Sticky Hop-bush	*Dodonaea viscosa*	2
Yellow Twin-heads	*Eclipta platyglossa* subsp. *platyglossa*	1
Nodding Saltbush	*Einadia nutans*	18
Ruby Saltbush	*Enchylaena tomentosa* var. *tomentosa*	25
Spreading Nut-heads	*Sphaeromorphaea australis*	4
Cane Grass	*Eragrostis australasica*	6

Common Name	Scientific Name	Records
Mallee Love-grass	*Eragrostis dielsii*	19
Purple Love-grass	*Eragrostis lacunaria*	3
Bristly Love-grass	*Eragrostis setifolia*	14
Berrigan	*Eremophila longifolia*	1
River Red-gum	*Eucalyptus camaldulensis*	7
Black Box	*Eucalyptus largiflorens*	13
Silky Browntop	*Eulalia aurea*	1
Indian Cudweed	*Gnaphalium polycaulon*	1
Pale Goodenia	*Goodenia glauca*	8
Rough Raspwort	*Haloragis aspera*	2
Blackseed Glasswort	*Tecticornia pergranulata*	29
Common Sunray	*Triptilodiscus pygmaeus*	1
Pygmy Sunray	*Rhodanthe pygmaea*	1
Tussock Rush	*Juncus aridicola*	2
Native Peppercress	*Lepidium pseudohyssopifolium*	4
Short-leaf Bluebush	*Maireana brevifolia*	7
Hairy Bluebush	*Maireana pentagona*	5
Erect Bluebush	*Maireana pentatropis*	2
Sago Bush	*Maireana pyramidata*	1
Woolly-fruit Bluebush	*Eriochiton sclerolaenoides*	1
Three-wing Bluebush	*Maireana triptera*	2
Common Nardoo	*Marsilea drummondii*	3
Creeping Monkey-flower	*Mimulus repens*	1
Tangled Lignum	*Duma florulenta*	15
Woolly-heads	*Myriocephalus rhizocephalus*	1
Poached-eggs Daisy	*Polycalymma stuartii*	8
Pimelea Daisy-bush	*Olearia pimeleoides*	5
Grassland Wood-sorrel	*Oxalis perennans*	1
Warrego Summer-grass	*Paspalidium jubiflorum*	37
Weeping Pittosporum	*Pittosporum angustifolium*	1
Dark Plantain	*Plantago drummondii*	3
Crowned Plantain	*Plantago turrifera*	1
Wiry Podolepis	*Podolepis capillaris*	2
Tough Scurf-pea	*Cullen tenax*	4
Yellow Tails	*Ptilotus nobilis* var. *nobilis*	1
Inland Buttercup	*Ranunculus pentandrus* var. *platycarpus*	1
Hedge Saltbush	*Rhagodia spinescens*	3
Prickly Saltwort	*Salsola tragus*	9
Sarcozona	*Sarcozona praecox*	6
Short-wing Saltbush	*Sclerochlamys brachyptera*	9
Grey Copperburr	*Sclerolaena diacantha*	15
Limestone Copperburr	*Sclerolaena obliquicuspis*	1
Streaked Copperburr	*Sclerolaena tricuspis*	18
Slender Groundsel	*Senecio glossanthus* s.l.	7
Variable Groundsel	*Senecio pinnatifolius*	3
Sand Sida	*Sida ammophila*	2
Variable Sida	*Sida corrugata*	3

Common Name	Scientific Name	Records
Quena	*Solanum esuriale*	17
Coast Sand-spurrey	*Spergularia media* s.l.	2
Yakka Grass	*Sporobolus caroli*	2
Rat-tail Couch	*Sporobolus mitchellii*	45
Star Bluebush	*Stelligera endecaspinis*	2
Rough Spear-grass	*Austrostipa scabra* subsp. *falcata*	5
Balcarra Spear-Grass	*Austrostipa nitida*	1
Small-leaf Swainson-pea	*Swainsona microphylla*	3
Grey Germander	*Teucrium racemosum* s.l.	2
Spurred Arrowgrass	*Triglochin calcitrapa* s.l.	2
Dwarf Arrowgrass	*Triglochin nana*	2
Annual New Holland Daisy	*Vittadinia cervicularis*	1
Fuzzy New Holland Daisy	*Vittadinia cuneata*	1
Dissected New Holland Daisy	*Vittadinia dissecta* s.l.	5
Woolly New Holland Daisy	*Vittadinia gracilis*	2
Tufted Bluebell	*Wahlenbergia communis* s.l.	1
River Bluebell	*Wahlenbergia fluminalis*	1
Pale Twin-leaf	*Zygophyllum glaucum*	1
Mat Saltbush	*Atriplex pumilio*	7
Common Swamp Wallaby-grass	*Amphibromus nervosus*	1
Southern Cane-grass	*Eragrostis infecunda*	4
Sandhill Spurge	*Phyllanthus lacunellus*	1
Mallee Annual-bluebell	*Wahlenbergia tumidifructa*	1
Climbing Twin-leaf	*Zygophyllum eremaeum*	2
Variable Daisy	*Brachyscome ciliaris* var. *ciliaris*	1
Slender Hop-bush	*Dodonaea viscosa* subsp. *angustissima*	6
Grey Willow-herb	*Epilobium billardierianum* subsp. *cinereum*	1
Spiny-fruit Saltbush	*Atriplex spinibractea*	3
Blue Rod	*Stemodia florulenta*	7
Squat Picris	*Picris squarrosa*	1
Kneed Swainson-pea	*Swainsona reticulata*	5
Grey Roly-poly	*Sclerolaena muricata* var. *villosa*	1
Variable Sida (narrow-lf form)	*Sida corrugata* var. *angustifolia*	1
Black Roly-poly	*Sclerolaena muricata* var. *muricata*	1
Annual New Holland Daisy	*Vittadinia cervicularis* var. *subcervicularis*	1
Dissected New Holland Daisy	*Vittadinia dissecta* var. *hirta*	1
Lesser Joyweed	*Alternanthera denticulata* s.s.	4
Salt Sea-spurrey	*Spergularia brevifolia*	2
Woolly Mantle	*Eriochlamys behrii* s.s.	1
Nodding Saltbush (matted form)	*Einadia nutans* (matted form)	3
Grass	*Poaceae* spp.	2
Bent/Blown Grass	*Agrostis* s.l. spp.	1
Saltbush	*Atriplex* spp.	3
Hop Bush	*Dodonaea* spp.	6
Love Grass	*Eragrostis* spp.	2
Spurge	*Euphorbia* spp.	2
Goodenia	*Goodenia* spp.	3

Common Name	Scientific Name	Records
Peppercress	*Lepidium* spp.	1
Nardoo	*Marsilea* spp.	1
Panic Grass	*Paspalidium* spp.	2
Copperburr	*Sclerolaena* spp.	2
Spear Grass	*Austrostipa* spp.	3
Swainson Pea	*Swainsona* spp.	4
New Holland Daisy	*Vittadinia* spp.	5

Flora – Exotic

Common Name	Scientific Name	Records
Great Brome	*Bromus diandrus*	3
Cape weed	*Arctotheca calendula*	4
Aster-weed	*Aster subulatus*	1
Mediterranean Turnip	*Brassica tournefortii*	22
Red Brome	*Bromus rubens*	12
Malta Thistle	*Centaurea melitensis*	1
Skeleton Weed	*Chondrilla juncea*	1
Flaxleaf Fleabane	*Conyza bonariensis*	2
Ferny Cotula	*Cotula bipinnata*	3
Water Buttons	*Cotula coronopifolia*	3
Drain Flat-sedge	*Cyperus eragrostis*	1
Barnyard Grass	*Echinochloa crus-galli*	1
Spiny Emex	*Emex australis*	1
Terracina Spurge	*Euphorbia terracina*	2
Common Heliotrope	*Heliotropium europaeum*	1
Hairy Rupture-wort	*Herniaria cinerea*	1
Smooth Cat's-ear	*Hypochaeris glabra*	18
Prickly Lettuce	*Lactuca serriola*	5
Common Peppercress	*Lepidium africanum*	1
Wimmera Rye-grass	*Lolium rigidum*	1
Tiny Bristle-grass	*Rostraria pumila*	3
African Box-thorn	*Lycium ferocissimum*	4
Little Medic	*Medicago minima*	8
Burr Medic	*Medicago polymorpha*	4
Small Ice-plant	*Mesembryanthemum nodiflorum*	11
Tripteris	*Monoculus monstrosus*	13
Coast Barb-grass	*Parapholis incurva*	4
Slender Barb-grass	*Parapholis strigosa*	1
False Hair-grass	*Pentameris airoides* subsp. *airoides*	5
Annual Beard-grass	*Polypogon monspeliensis*	1

Common Name	Scientific Name	Records
Giant Mustard	*Rapistrum rugosum*	1
False Sow-thistle	*Reichardia tingitana*	11
Arabian Grass	*Schismus barbatus*	3
Mediterranean Catchfly	*Silene nocturna*	1
Smooth Mustard	*Sisymbrium erysimoides*	2
London Rocket	*Sisymbrium irio*	2
Black Nightshade	*Solanum nigrum* s.l.	1
Rough Sow-thistle	*Sonchus asper* s.l.	1
Common Sow-thistle	*Sonchus oleraceus*	17
Lesser Sand-spurrey	*Spergularia diandra*	3
Red Sand-spurrey	*Spergularia rubra* s.l.	3
Stinking Roger	*Tagetes minuta*	3
Trailing Verbena	*Verbena supina*	1
Wandering Speedwell	*Veronica peregrina*	1
Rat's-tail Fescue	*Vulpia myuros*	7
Bathurst Burr	*Xanthium spinosum*	1
Barley-grass	*Hordeum murinum* s.l.	13
Mallee Catchfly	*Silene apetala* var. *apetala*	2
Rat's-tail Fescue	*Vulpia myuros* f. *myuros*	1
Red Sand-spurrey	*Spergularia rubra* s.s.	7
Oat	*Avena* spp.	1
Fleabane	*Conyza* spp.	1

Fauna – Native

Common Name	Scientific Name	Type	Records
Common Yabby	*Cherax destructor destructor*	I	1
Freshwater Shrimp	*Paratya* spp	I	100
Freshwater Prawn	*Macrobrachium*	I	100
Murray-Darling Rainbow fish	*Melanotaenia fluviatilis*	F	5
Golden Perch	*Macquaria ambigua*	F	6
Carp Gudgeon	*Hypseleotris* spp	F	233
Fly-specked hardyhead	*Craterocephalus stercusmuscarum*	F	1
Bony Bream	*Nematalosa erebi*	F	106
Eastern Long-Necked Turtle	*Chelodina longicollis*	R	7
Little Pied Cormorant	*Microcarbo melanoleucos*	B	9
Pied Butcherbird	*Cracticus nigrogularis*	B	4
Emu	*Dromaius novaehollandiae*	B	1
Stubble Quail	*Coturnix pectoralis*	B	1

Common Name	Scientific Name	Type	Records
Peaceful Dove	*Geopelia striata*	B	7
Common Bronzewing	*Phaps chalcoptera*	B	6
Crested Pigeon	*Ocyphaps lophotes*	B	7
Wonga Pigeon	*Leucosarcia melanoleuca*	B	1
Australian Spotted Crake	*Porzana fluminea*	B	2
Black-tailed Native-hen	*Gallinula ventralis*	B	5
Dusky Moorhen	*Gallinula tenebrosa*	B	4
Purple Swamphen	*Porphyrio porphyrio*	B	3
Eurasian Coot	*Fulica atra*	B	1
Great Crested Grebe	*Podiceps cristatus*	B	1
Australasian Grebe	*Tachybaptus novaehollandiae*	B	5
Great Cormorant	*Phalacrocorax carbo*	B	10
Little Black Cormorant	*Phalacrocorax sulcirostris*	B	5
Pied Cormorant	*Phalacrocorax varius*	B	4
Darter	*Anhinga novaehollandiae*	B	4
Australian Pelican	*Pelecanus conspicillatus*	B	7
Caspian Tern	*Hydroprogne caspia*	B	1
Silver Gull	*Chroicocephalus novaehollandiae*	B	2
Red-kneed Dotterel	*Erythrogonys cinctus*	B	3
Masked Lapwing	*Vanellus miles*	B	8
Banded Lapwing	*Vanellus tricolor*	B	1
Red-capped Plover	*Charadrius ruficapillus*	B	1
Black-fronted Dotterel	*Elseyornis melanops*	B	3
Red-necked Stint	*Calidris ruficollis*	B	2
Sharp-tailed Sandpiper	*Calidris acuminata*	B	2
Great Knot	*Calidris tenuirostris*	B	1
Sanderling	*Calidris alba*	B	1
Brolga	*Grus rubicunda*	B	1
Glossy Ibis	*Plegadis falcinellus*	B	1
Australian White Ibis	*Threskiornis molucca*	B	6
Straw-necked Ibis	*Threskiornis spinicollis*	B	2
Royal Spoonbill	*Platalea regia*	B	1
Yellow-billed Spoonbill	*Platalea flavipes*	B	3
Intermediate Egret	*Ardea intermedia*	B	1
Eastern Great Egret	*Ardea modesta*	B	7
White-faced Heron	*Egretta novaehollandiae*	B	12
White-necked Heron	*Ardea pacifica*	B	4
Nankeen Night Heron	*Nycticorax caledonicus hillii*	B	5
Australian Wood Duck	*Chenonetta jubata*	B	11

Common Name	Scientific Name	Type	Records
Black Swan	*Cygnus atratus*	B	3
Australian Shelduck	*Tadorna tadornoides*	B	5
Pacific Black Duck	*Anas superciliosa*	B	10
Grey Teal	*Anas gracilis*	B	12
Australasian Shoveler	*Anas rhynchotis*	B	1
Pink-eared Duck	*Malacorhynchus membranaceus*	B	2
Hardhead	*Aythya australis*	B	2
Blue-billed Duck	*Oxyura australis*	B	1
Musk Duck	*Biziura lobata*	B	2
Swamp Harrier	*Circus approximans*	B	2
Brown Goshawk	*Accipiter fasciatus*	B	2
Collared Sparrowhawk	*Accipiter cirrhocephalus*	B	1
Wedge-tailed Eagle	*Aquila audax*	B	3
Little Eagle	*Hieraaetus morphnoides*	B	2
White-bellied Sea-Eagle	*Haliaeetus leucogaster*	B	4
Whistling Kite	*Haliastur sphenurus*	B	10
Black Kite	*Milvus migrans*	B	4
Black-shouldered Kite	*Elanus axillaris*	B	1
Australian Hobby	*Falco longipennis*	B	1
Peregrine Falcon	*Falco peregrinus*	B	4
Nankeen Kestrel	*Falco cenchroides*	B	6
Southern Boobook	*Ninox novaeseelandiae*	B	1
Pacific Barn Owl	*Tyto javanica*	B	1
Sulphur-crested Cockatoo	*Cacatua galerita*	B	6
Major Mitchell's Cockatoo	*Lophocroa leadbeateri*	B	3
Little Corella	*Cacatua sanguinea*	B	6
Galah	*Eolophus roseicapilla*	B	12
Cockatiel	*Nymphicus hollandicus*	B	1
Regent Parrot	*Polytelis anthopeplus monarchoides*	B	10
Crimson Rosella	*Platycercus elegans*	B	3
Pale-headed Rosella	*Platycercus adscitus*	B	1
Red-rumped Parrot	*Psephotus haematonotus*	B	7
Mulga Parrot	*Psephotus varius*	B	1
Blue Bonnet	*Northiella haematogaster*	B	2
Budgerigar	*Melopsittacus undulatus*	B	1
Tawny Frogmouth	*Podargus strigoides*	B	1
Australian Owlet-nightjar	*Aegotheles cristatus*	B	1
Laughing Kookaburra	*Dacelo novaeguineae*	B	10
Forest Kingfisher	*Todiramphus macleayii*	B	1

Common Name	Scientific Name	Type	Records
Red-backed Kingfisher	*Todiramphus pyrropygia pyrropygia*	B	1
Sacred Kingfisher	*Todiramphus sanctus*	B	7
Rainbow Bee-eater	*Merops ornatus*	B	5
Pallid Cuckoo	*Cuculus pallidus*	B	2
Fan-tailed Cuckoo	*Cacomantis flabelliformis*	B	1
Horsfield's Bronze-Cuckoo	*Chrysococcyx basalis*	B	4
Welcome Swallow	*Petrochelidon neoxena*	B	11
White-backed Swallow	*Cheramoeca leucosternus*	B	1
Tree Martin	*Petrochelidon nigricans*	B	8
Fairy Martin	*Petrochelidon ariel*	B	2
Grey Fantail	*Rhipidura albiscarpa*	B	1
Willie Wagtail	*Rhipidura leucophrys*	B	16
Restless Flycatcher	*Myiagra inquieta*	B	1
Red-capped Robin	*Petroica goodenovii*	B	7
Hooded Robin	*Melanodryas cucullata cucullata*	B	2
Rufous Whistler	*Pachycephala rufiventris*	B	8
Grey Shrike-thrush	*Colluricincla harmonica*	B	8
Magpie-lark	*Grallina cyanoleuca*	B	12
Crested Shrike-tit	*Falcunculus frontatus*	B	1
Crested Bellbird	*Oreoica gutturalis gutturalis*	B	1
Ground Cuckoo-shrike	*Coracina maxima*	B	3
Black-faced Cuckoo-shrike	*Coracina novaehollandiae*	B	7
White-winged Triller	*Lalage sueurii*	B	2
Chestnut Quail-thrush	*Cinclosoma castanotus*	B	1
White-browed Babbler	*Pomatostomus superciliosus*	B	3
Chestnut-crowned Babbler	*Pomatostomus ruficeps*	B	1
White-fronted Chat	*Epthianura albifrons*	B	6
Crimson Chat	*Epthianura tricolor*	B	1
Western Gerygone	*Gerygone fusca*	B	1
Weebill	*Smicrornis brevirostris*	B	7
Southern Whiteface	*Aphelocephala leucopsis*	B	5
Yellow Thornbill	*Acanthiza nana*	B	2
Chestnut-rumped Thornbill	*Acanthiza uropygialis*	B	7
Yellow-rumped Thornbill	*Acanthiza chrysorrhoa*	B	4
Little Grassbird	*Megalurus gramineus*	B	5
Clamorous Reed Warbler	*Acrocephalus stentoreus*	B	3
Mallee Emu-wren	*Stipiturus mallee*	B	1
Superb Fairy-wren	*Malurus cyaneus*	B	1
Splendid Fairy-wren	*Malurus splendens*	B	6

Common Name	Scientific Name	Type	Records
White-winged Fairy-wren	*Malurus leucopterus*	B	4
Variegated Fairy-wren	*Malurus lamberti*	B	6
White-breasted Woodswallow	*Artamus leucorynchus*	B	1
Masked Woodswallow	*Artamus personatus*	B	3
White-browed Woodswallow	*Artamus superciliosus*	B	3
Black-faced Woodswallow	*Artamus cinereus*	B	1
Dusky Woodswallow	*Artamus cyanopterus*	B	1
Varied Sittella	*Daphoenositta chrysoptera*	B	3
White-browed Treecreeper	*Climacteris affinis*	B	1
Mistletoebird	*Dicaeum hirundinaceum*	B	2
Silvereye	*Zosterops lateralis*	B	3
Striped Honeyeater	*Plectorhyncha lanceolata*	B	4
Black Honeyeater	*Sugamel niger*	B	3
White-fronted Honeyeater	*Phylidonyris albifrons*	B	1
Pied Honeyeater	*Certhionyx variegatus*	B	1
Singing Honeyeater	*Lichenostomus virescens*	B	3
Yellow-faced Honeyeater	*Lichenostomus chrysops*	B	1
White-plumed Honeyeater	*Lichenostomus penicillatus*	B	16
Noisy Miner	*Manorina melanocephala*	B	10
Yellow-throated Miner	*Manorina flavigula*	B	3
Spiny-cheeked Honeyeater	*Acanthagenys rufogularis*	B	5
Blue-faced Honeyeater	*Entomyzon cyanotis*	B	5
Little Friarbird	*Philemon citreogularis*	B	6
Australasian Pipit	*Anthus novaeseelandiae*	B	5
Diamond Firetail	*Stagonopleura guttata*	B	1
Zebra Finch	*Taeniopygia guttata*	B	6
Spotted Bowerbird	*Ptilonorhynchus maculatus*	B	1
White-winged Chough	*Corcorax melanorhamphos*	B	3
Grey Currawong	*Strepera versicolor*	B	1
Grey Butcherbird	*Cracticus torquatus*	B	7
Australian Magpie	*Gymnorhina tibicen*	B	13
Australian Raven	*Corvus coronoides*	B	12
Little Raven	*Corvus mellori*	B	2
Striated Pardalote	*Pardalotus striatus*	B	7
Short-beaked Echidna	*Tachyglossus aculeatus*	M	1
Common Ringtail Possum	*Pseudocheirus peregrinus*	M	1
Feathertail Glider	*Acrobates pygmaeus*	M	1
Western Grey Kangaroo	*Macropus fuliginosus*	M	2
Short-nosed Bandicoot (inland form)	*Isoodon* sp. (c.f. *auratus*)	M	1

Common Name	Scientific Name	Type	Records
Marbled Gecko	*Christinus marmoratus*	R	2
Barking Marsh Frog	*Limnodynastes fletcheri*	A	1
Spotted Marsh Frog (race unknown)	*Limnodynastes tasmaniensis*	A	2
Plains Froglet	*Crinia parinsignifera*	A	4
Peron's Tree Frog	*Litoria peronii*	A	3
Yellow Rosella	*Platycercus elegans flaveolus*	B	7
Mallee Ringneck	*Barnardius zonarius barnardi*	B	2
Brown Treecreeper (south-eastern	*Climacteris picumnus victoriae*	B	11
Black-winged Stilt	*Himantopus himantopus*	B	3

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

Fauna – Exotic

Common Name	Scientific Name	Type	Records
Common Starling	*Sturnus vulgaris*	B	7
House Sparrow	*Passer domesticus*	B	4
European Goldfinch	*Carduelis carduelis*		
Red Fox	*Vulpes vulpes*	M	1

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

APPENDIX 2 ECOLOGICAL VEGETATION CLASSES

Appendix 2 provides a description of each EVC within the Karadoc target area.

EVC no.	EVC name	Bioregional Conservation Status Robinvale Plains Fans	Description
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.
98	Semi-arid Chenopod Woodland	Vulnerable	Sparse, low non-eucalypt woodland to 12 m tall of the arid zone with a tall open chenopod shrub-dominated understorey or a treeless, tall chenopod shrubland to 3 m tall. This EVC may occur as either a woodland (typically with a very open structure but tree cover >10%) or a shrubland (tree cover <10%) with trees as an occasional emergent.
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.
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.
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 3 CULTURAL HERITAGE CONTINGENCY PLAN

CONTINGENCY PLANS

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

1 Management of Aboriginal Cultural Heritage found during the Activity

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

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

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

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

1. Discovery:

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

2. Notification:

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

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

3. Impact Mitigation or Salvage:

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

4. Curation and Further Analysis:

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

5. Reburial:

- Any reburial site(s) must be fully documented by an experienced and qualified archaeologist, clearly marked and all details provide to AAV;
- Appropriate management measures must be implemented to ensure that the remains are not disturbed in the future.