# Butlers Creek Environmental Water Management Plan

mallee
catchment management authority

# Document Control

| Version Number | Description | Issued To | Issue Date |
|---|---|---|---|
| 1. | Draft for project team review | M. Cooling | 17/3/2016 |
| 2. | Draft 1 for CMA review | E. Healy | 30/3/2016 |
| 3. | Draft 2 for CMA review | E. Healy | 18/04/2016 |
| 4. | Final Draft | E. Healey | 27/04/2016 |

### Citation

Please cite this document as:

Riverness and Ecological Associates (2016) Butlers Creek Environmental Water Management Plan, Report prepared for Mallee CMA, Mildura Victoria

### Contact

For queries regarding this document, please contact:

**James Kellerman**
General Manager Operations and Community
James.Kellerman@malleecma.com.au

# Table of contents

# 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 Butlers Creek, which is part of the Kings Billabong WMU sub-unit and the Nichols Point WMU. The EWMP will help to guide future environmental watering activities for this area.

The features to be incorporated in the new Butlers Creek EWMP are Butlers Creek, Ducksfoot Lagoon and Baggs Lagoon.

Butlers Creek provides the preferred habitat for the endangered Freshwater Catfish and the vulnerable Growling Grass Frog. Breeding of large wading birds could be supported in the flooded Lignum vegetation communities within Ducksfoot Lagoon, and large numbers of piscivorous water birds will be supported by high levels of aquatic productivity and the abundant fish community. Butlers Creek is a high profile site for environmental watering with high numbers of visitors to the Kings Billabong Park and the close proximity to Mildura.

The management goal for the Butlers Creek EWMP is “The Butlers Creek target area to be permanent wetlands with seasonal variation in water levels that will support the populations of Growling Grass Frog and Freshwater Catfish and support key habitat requirements of piscivorous and large wading birds.”

To achieve this goal, the following ecological objectives have been identified:

*All water areas*

- Self-sustaining population of Growling Grass Frogs
- Self-sustaining population of Freshwater Catfish
- Maintain high levels of aquatic productivity
- Feeding by piscivorous waterbirds

*Ducksfoot and Baggs Lagoons*

- Foraging and breeding by large wading birds

Butlers Creek, Baggs Lagoon and Ducksfoot Lagoon are to be managed as a permanently inundated water area with seasonal variations in water level. The optimal watering regime for Butlers Creek is to fill wetlands to 34.9m AHD every spring/summer allowing natural drawdown of the level during autumn. Ensure that permanent open water habitat is maintained by ensuring that water levels do not fall below 33.9m AHD by opening the regulator gate. Every three years fill wetland to 34.9m AHD and maintain this level for seven months to facilitate waterbird breeding and flushing of sediment. Top up as required.

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

There are no additional infrastructure requirements at Butlers Creek.

# 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 Butlers Creek.

The key purposes of the EWMP are to:

- identify long-term objectives and water requirements for the wetland, which has been identified as a high priority reach by the Mallee CMA;
- provide a vehicle for community consultation, including for the long-term objectives and water requirements of the wetlands;
- inform the development of seasonal watering proposals and seasonal watering plans; and
- inform the long-term watering plans to be developed under the Basin Plan requirements.

# 2 Site overview

## 2.1 Site location

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

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

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

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

The site for this plan is Butlers Creek, 15km south east of Mildura (Figure 1). Butlers Creek is located within the Nichols Point WMU, the Kings Billabong WMU sub-unit, and has previously been included in the Kings Billabong EWMP.

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

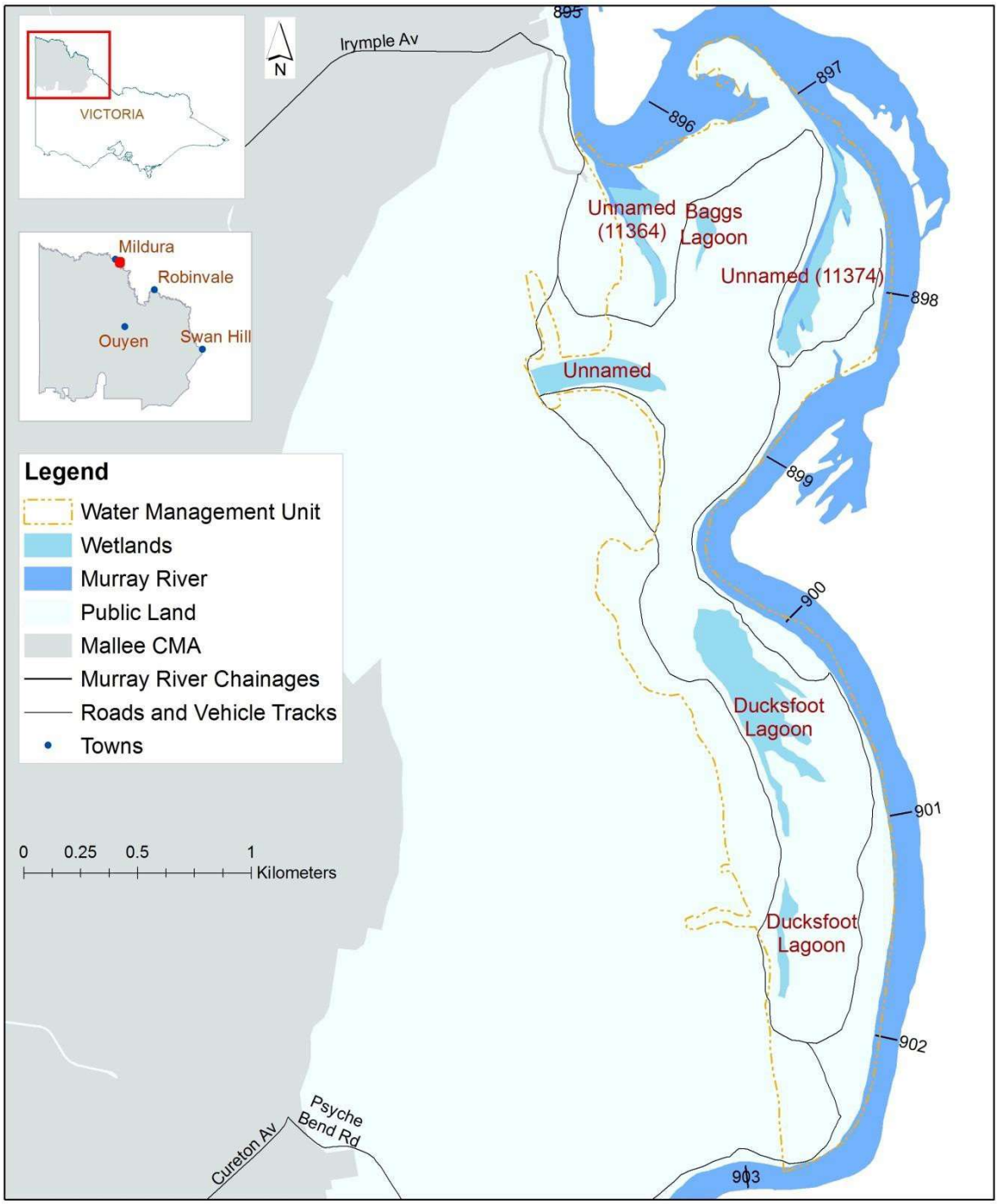



**Figure 1 – Butlers Creek**

## 2.2 Catchment setting

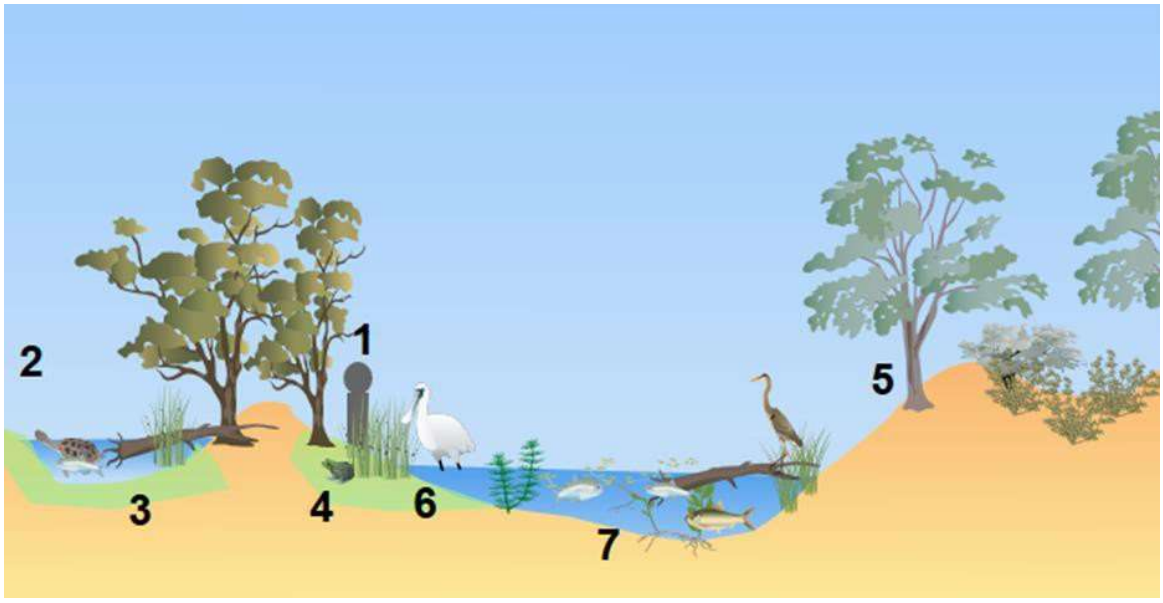
Butlers Creek is in the Robinvale Plains bioregion within the Mallee CMA region. The Robinvale Plains Bioregion is characterised by a narrow gorge confined by the cliffs along the Murray River, which is entrenched within older up-faulted Cainozoic sedimentary rocks. Alluvium deposits from the Cainozoic period gave rise to the red brown earths, cracking clays and texture contrast soils (Dermosols, Vertosols, Chromosols and Sodosols) which support Riverine Grassy Forest and Riverine Grassy Chenopod Woodland Ecosystems(DEPI, 2015).

## 2.3 Butlers Creek

Butlers Creek is located within Kings Billabong Park. Butlers Creek has previously been included in the Kings Billabong EWMP (2011). The features to be incorporated in the new Butlers Creek EWMP are Butlers Creek, Ducksfoot Lagoon and Baggs Lagoon. These features are able to be connected to the Murray River at lower levels than Kings Billabong itself. Until recently Ducksfoot Lagoon was permanently full at the normal operating level of the Mildura Weir (Lock 11); however a regulator has been installed to provide a wetting and drying regime in the wetland.

## 2.4 Conceptualisation of the site

A conceptual model of the hydrological and ecological characteristics of Butlers Creek is presented below. This is a visual representation of the processes and components within the target area that are discussed throughout this EWMP.




Butlers Creek is located west of Mildura within the Kings Billabong Park. It was formerly included within the Kings Billabong EWMP.

1. Butlers Creek, Ducksfoot Lagoon and Baggs Lagoon are floodplain wetlands and anabranches which are connected to the Murray River at lower levels than Kings Billabong.
   Prior to river regulation the wetlands were ephemeral with a water regime driven by flows and flooding from the Murray River. Until recently, the water levels within the wetlands were controlled by the Mildura weir; the construction of two regulators has allowed the reestablishment of a wetting and drying cycle within the wetlands.
2. Butlers Creek connects Baggs Lagoon and Ducksfoot Lagoon to the Murray River.
   Within Butlers Creek, woody habitat, fringing emergent macrophytes and submerged macrophytes provide excellent habitat for small and large bodied native fish, turtles and frogs.
3. The slow flowing water of Butlers Creek provides excellent Freshwater Catfish habitat. Freshwater Catfish require woody debris and seasonal fluctuations in water levels to encourage macrophyte growth, primary productivity and aquatic invertebrate populations. Occasional scouring flows are required to remove sediment.
4. Growling Grass Frog is present at the site and requires annual inundation of the littoral zone to provide marshy habitat. Growling Grass Frog also require inundation during their breeding season and a permanent aquatic refuge.
5. Vegetation surrounding the wetlands gradually transitions from Intermittent Swampy Woodland to Lignum Shrubland in less frequently inundated areas.
6. Ducksfoot Lagoon is over 2 metres deep in its deepest section. Fringing macrophytes, submerged macrophytes and large woody debris provide a range of habitat conditions for waterbirds and fish. Shallow water habitat supports foraging, nesting and recruitment of large waders. Deeper open water provides feeding opportunities for piscivorous waterbirds. Fluctuation of water levels and summer drawdown will encourage primary productivity, expose mud flats and marshy habitat for wader birds and frogs, and discourage growth of Cumbungi.
7. Ducksfoot Lagoon can also support a diverse small and large bodied native fish community.

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

## 2.5 Land status and management

Several agencies and individuals are involved in managing the land and water at Butlers Creek (Table 1). Land management boundaries are shown in Figure 2.

Parks Victoria is the land manager of Kings Billabong Park.

**Table 1 - Stakeholders for the Butlers Creek EWMP**

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

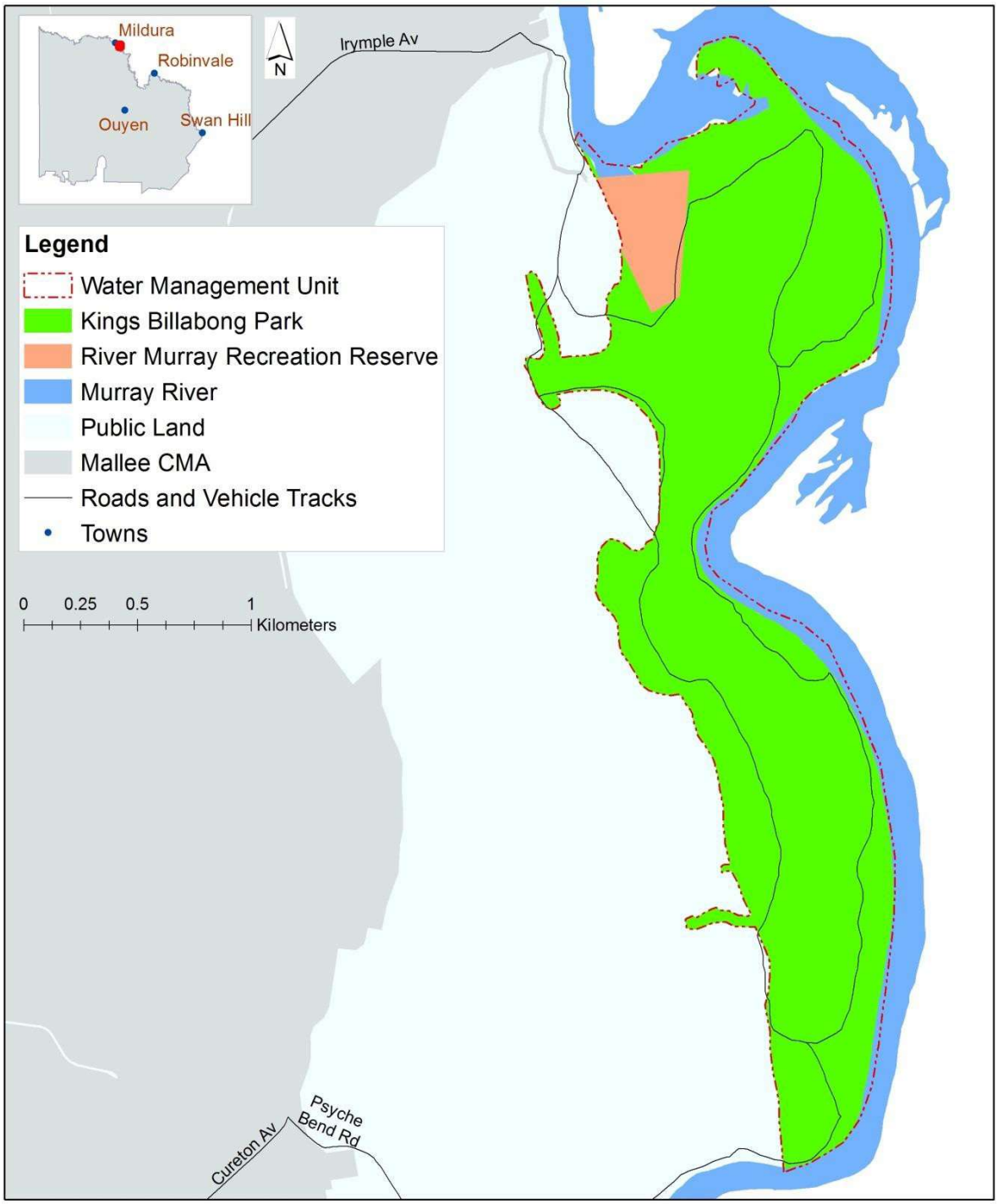



**Figure 2 - Land management boundaries within Butlers Creek**

## 2.6 Wetland characteristics

A brief overview of the main characteristics of the wetlands at Butlers Creek is provided in Table 2. Wetland types found within Butlers Creek are shown in Figure 3.

**Table 2 - Wetland characteristics at Butlers Creek**

| Characteristics | Description |
|---|---|
| Name | Butlers Creek |
| Mapping ID (Wetland Current layer) | Ducksfoot Lagoon: 11371, 11373<br>Baggs Lagoon: 11367<br>Butlers Creek<br>Unnamed wetland: 11364<br>Unnamed wetland: 11374 |
| Area of wetlands in target area | 49.74 ha |
| Bioregion | Robinvale Plains |
| Conservation status | The wider Kings Billabong area (which includes Ducksfoot Lagoon and Baggs Lagoon) is listed as a nationally important wetland in the Directory of Important Wetlands in Australia (DIWA)<br>Bioregion conservation status: areas of EVCs listed as Depleted and Least Concern |
| Land status | Public Land: Kings Billabong Park and River Murray Recreation Reserve |
| Land manager | Parks Victoria, DELWP |
| Surrounding land use | Dryland cropping, irrigated agriculture (grapes, dried fruit), town of Irymple |
| Water supply | Natural inflows from the Murray River and local catchment runoff |
| Wetland category (Wetland Current layer) | Ducksfoot Lagoon; Permanent freshwater lakes<br>Baggs Lagoon: Permanent freshwater lakes<br>Butlers Creek – N/A<br>Unnamed wetland: 11364: Permanent freshwater lakes<br>Unnamed wetland: 11374: Permanent freshwater lakes |
| Wetland depth at capacity | Greater than 2 metres at deepest point |

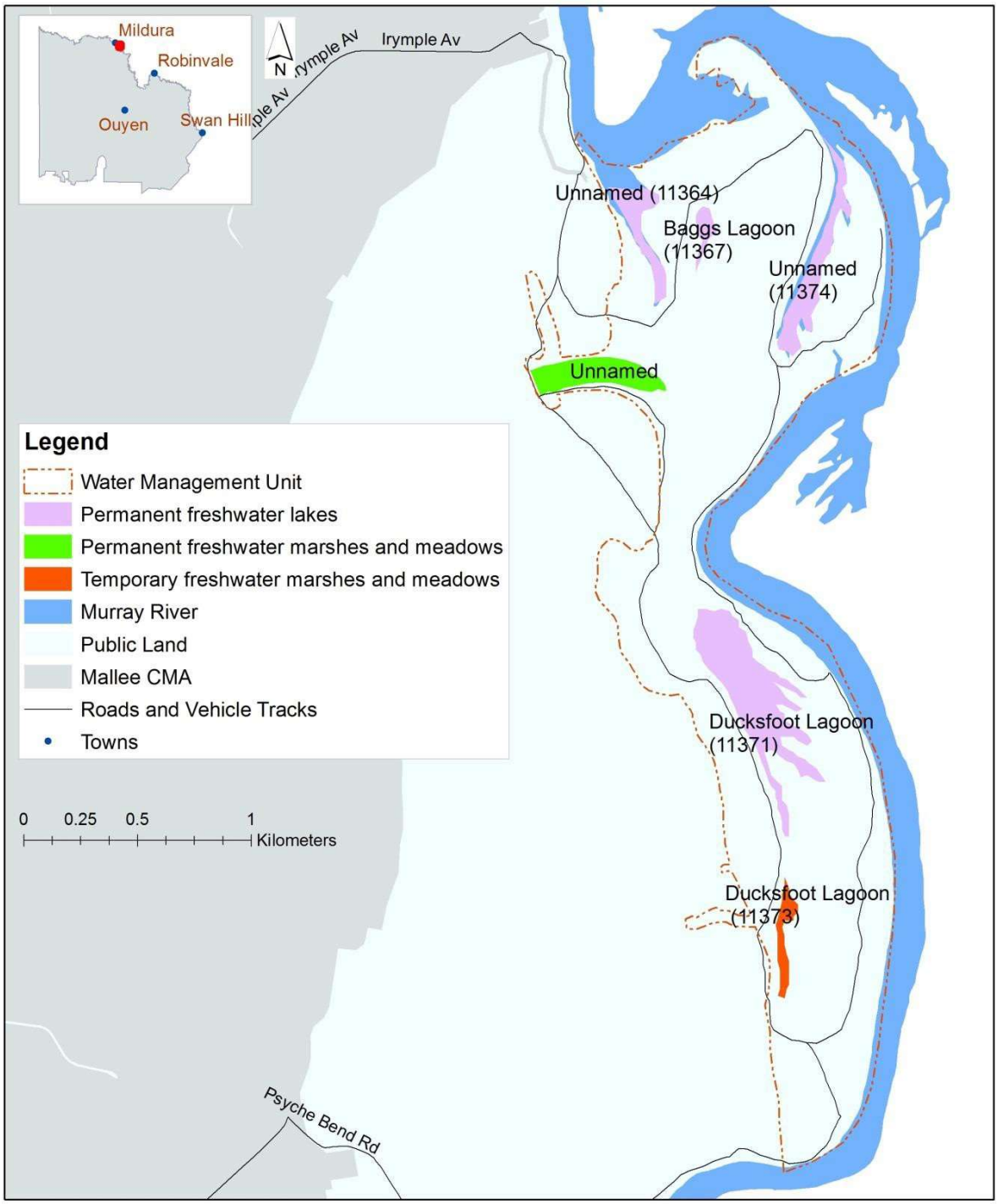



**Figure 3 - Wetland types found within Butlers Creek**

## 2.7 Management scale

The whole of Butlers Creek has a water requirement as a floodplain complex, but the focus of this plan is restricted to a target area of 49.74 ha, as shown as the maximum inundation extent in Figure 4. This target area, consisting of Butlers Creek, Baggs Lagoon and Ducksfoot Lagoon, is the area of Butlers Creek that is able to be managed with environmental water using the existing infrastructure.

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

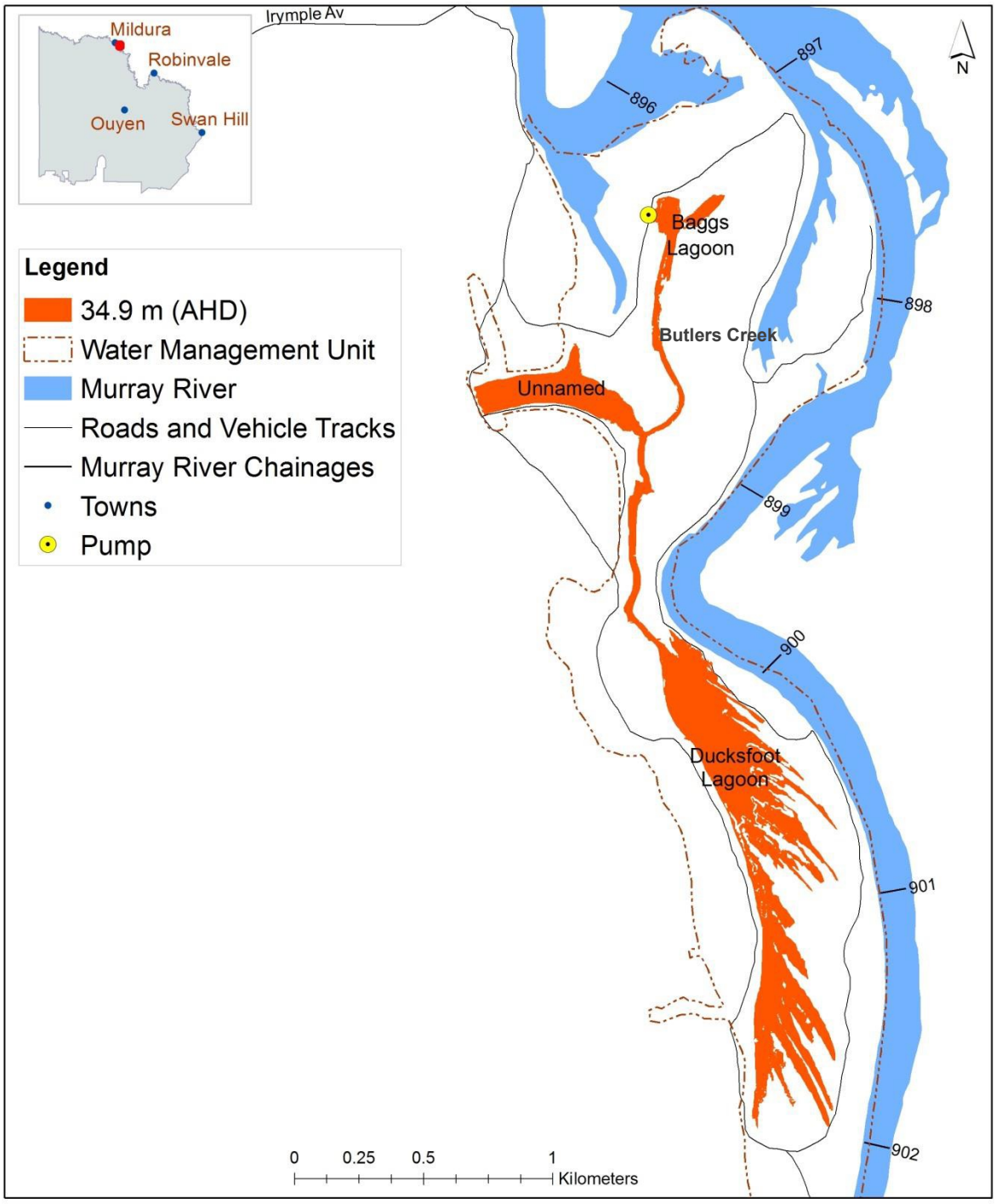



**Figure 4 - Target area for the Butlers Creek EWMP consisting of the areas shown in the maximum inundation extent.**

## 2.8 Environmental water sources

The Environmental Water Reserve (EWR) is the legally recognised amount of water set aside to meet environmental needs. The EWR can include minimum river flows, unregulated flows and

specific environmental entitlements. Environmental entitlements can be called out of storage when needed and delivered to wetlands or streams to protect their environmental values and health.

The Victorian Environmental Water Holder (VEWH) is an independent body of the Victorian Government responsible for holding and managing Victoria's environmental water entitlements.

Environmental water for the target area may be sourced from the water entitlements listed in Table 3. The Regional Context Document (North, 2014) provides further detail. Previous environmental watering at Butlers Creek is outlined in the Environmental Watering section of this EWMP.

**Table 3 - Summary of environmental water sources available to Butlers Creek**

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

## 2.9 Related agreements, policy, plans and activities

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

**Table 4 - International conservation conventions, and national and state legislation relevant to management of the target area**

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

The Kings Billabong EWMP was drafted in 2011. This document is a full revision of the environmental watering requirements for the Butlers Creek target area.

The Mallee Waterway Strategy (2014) identifies Ducksfoot Lagoon as medium priority wetland in the Mallee CMA region and Butlers Creek is identified as a high priority river reach. Additionally, the Strategy identifies a number of specific management activities for Butlers Creek. These activities are:

- Deliver water as per EWMP (Management Action C1.2)
- Raise tracks near Baggs Bridge and Jennings Bridge regulators to increase effectiveness of environmental water events (C1.3)
- Investigate pest species control including:
    - Improved overall control at King's Billabong Park
    - European Carp movement in Butlers Creek, Ducksfoot Lagoon and Sandilong Creek (F1.2)
- Investigate options to improve fish passage to Butlers Creek and Ducksfoot Lagoon (F1.4)
- Review Ducksfoot Lagoon EWMP (this EWMP) to include investigations for water delivery to North-west Wetland (F1.5).

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

A number of earlier investigations into the Murray River floodplain are relevant to Butlers Creek EWMP and have been considered in the development of this EWMP. These include salinity management plans, flow studies and an investigation into River Red Gum health by the Land Conservation Council and the Victorian Environmental Assessment Council (VEAC, 2008).

Additionally, a number of specific studies have been undertaken at Butlers Creek and the wider King's Billabong area. These include assessments of sulfidic sediments (Baldwin, 2008; Chapman, Baldwin and Ellis, 2010), fish movement in response to drawdown of Butlers Creek (Ellis, Huntley, Lampard and Wood, 2015a), fish and aquatic vegetation monitoring (Ellis and Campbell, 2013). Butlers Creek was also one of the areas included in the Investigation of Water Management Options for the Murray River – Robinvale to Walpolla (Ecological Associates, 2007b).

DELWP, Parks Victoria and the Mallee CMA have invested resources into the area in recent years in both environmental watering and complementary on ground works.

A raised board walk extending 100 metres will provide continuity of the walking trail that would otherwise be inundated by the watering. The board walk will be installed by June 2016.

# 3 Hydrology and system operations

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

## 3.1 Hydrology

### Murray River hydrology

Murray River hydrology has been altered significantly by regulation and diversion upstream. Storages in Victoria and New South Wales are managed to capture water in winter and spring and to deliver this water at manageable flow rates to consumers (primarily irrigators) during the summer. The impact on river hydrology has been a reduction in large winter and spring flow peaks and enhancement of low summer flows. Locks and weirs have further altered floodplain water regimes by stabilising river levels.

The ecologically significant effects of these hydrological and hydraulic changes have been to:

- largely eliminate flowing water habitat under normal regulated flows;
- permanently inundate wetlands, the river channel and low-lying floodplain areas in the vicinity of the weir pools; and
- reduce the frequency and duration of floods that reach higher-level wetlands and floodplain areas.

Since there are no major tributaries or losses from the Murray River between Robinvale to Wallpolla Island, Ecological Associates (2007) suggest that the hydrology at Butlers Creek is best described using gauge #414203 (Murray River @ downstream of Euston Weir). The hydrology of the river at Butlers Creek has been characterised by analysing the MSM_Bigmod daily flow series for Natural and Current (Baseline scenarios, using data from 1891 to 2009 (Figure 5).

The river now spends more time fluctuating at very low flows, less than 10,000 ML/d, than under natural conditions as indicated by higher than natural spell frequency but much shorter spell duration. Events that inundate low-lying wetlands, between 30,000 and 60,000 ML/d, now occur at almost half the frequency of natural conditions. The duration of these events, when they do occur, has also been reduced by almost 60%. The impact on floodplain inundation is also significant. While the duration of spells exceeding 70,000 ML/d under current conditions is similar to natural, the frequency of these events has declined to as much as 50% of natural. This has resulted in a major increase in the interval between spells for very high flows.

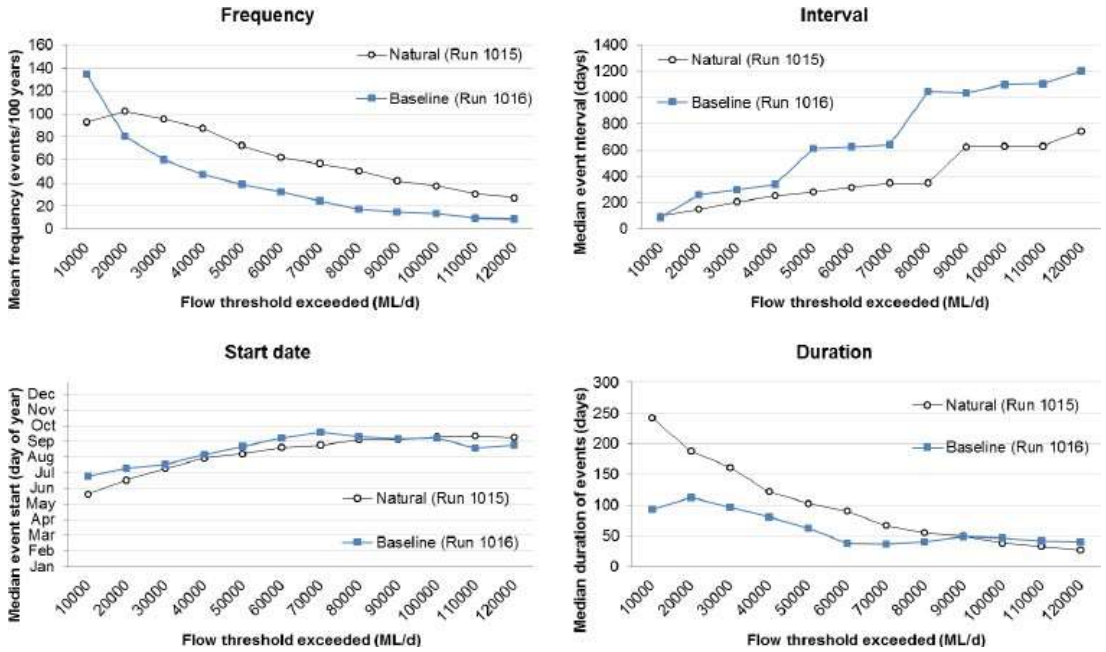



**Figure 5. Spells analysis for River Murray flows upstream of Lock 11 (using data from Euston DS) for Natural and Baseline scenarios over a 114 year modelled period (Fluvial Systems 2014)**

Mean annual flows at Euston have been reduced by 49 per cent from natural levels, although seasonality of mean monthly flows is largely unaltered (Maheshwari, Walker and McMahon, 1993; Ecological Associates, 2006a) as shown in Figure 6.

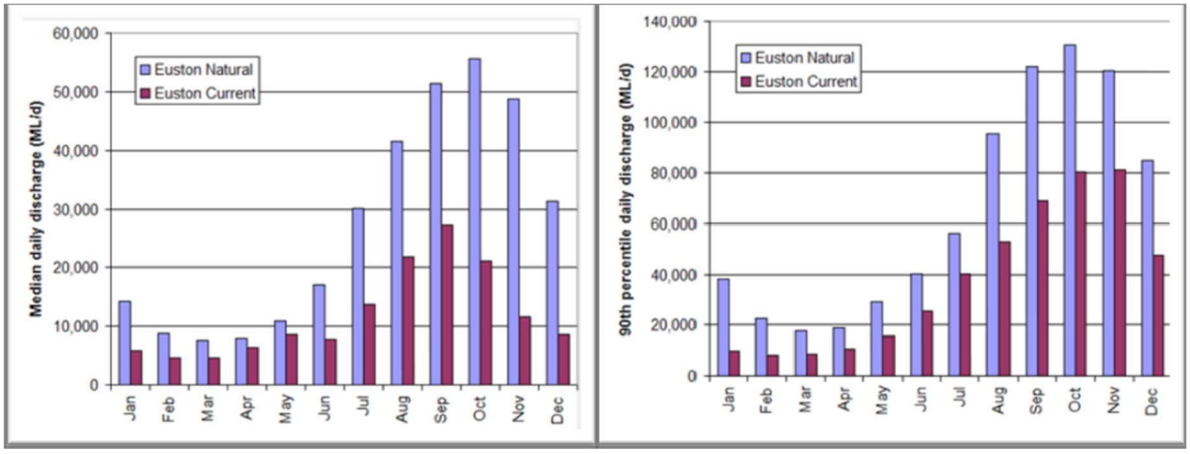



**Figure 6 - Distribution of median flows and 90th per centile flows for each month in the Murray River through Euston Weir for pre-regulated and regulated (current) conditions (Ecological Associates, 2006).**

### Wetland hydrology

It is estimated that water enters the Butlers Creek floodplain at 37,900 ML/day.

Under pre-regulation conditions the wetlands would have been inundated on average 87.7 times per 100 years compared with 47.4 times per 100 years post-regulation (Gippel, 2014). The median duration of inundation events has been reduced from 122 days to 81 days since river regulation (Gippel, 2014).

## 3.2 Hydraulic effects of the weirs

### Water level variability

The weirs are currently managed to create a stable level upstream, close to the capacity of the river channel. The weirs are opened and closed as flow varies, so a stable river level can be maintained. The weirs are effective until discharge at the weir exceeds the capacity of the structure. At this point the river levels below and above the weir equalise. If the weir cannot be opened any further, it is removed and rising discharge results in rising river levels.

Under current development and operating practices the weirs have raised the river to a level similar to the median annual peak, i.e. the spring seasonal level. Variation in river levels has been largely eliminated from the low-flow seasons of summer and autumn. In winter and spring median river levels are maintained close to the target pool level, but rare, high flows continue to provide elevated water levels.

### System operations at Butlers Creek

Until recently Butlers Creek was connected to the Lock 11 weir pool at its southern end (Jennings Bridge crossing) and northern end (Baggs Bridge crossing). The weir is operated to 34.4m AHD. Ducksfoot and Baggs Lagoons were also permanently inundated. Regulators were installed by the Mallee CMA in 2011 at the crossings to allow water levels to be operated independently of the weir pool.

### Environmental watering

Table 5 provides a summary of previous environmental watering.

**Table 5 - A summary of environmental watering at Butlers Creek**

| Water year | Time of inflow | Inflow source | Source volume (ML) | Total volume (ML) | Area (ha) inundated |
|---|---|---|---|---|---|
| 2013/2014 | November to January | VEWH | 600 ML | 600 ML | 60 ha |
| 2015/2016 | September | VEWH | 250 ML | 102.8 ML | 38.3 ha |

Following the installation of the regulators at Baggs Bridge and Ducksfoot Lagoon, a drying cycle regime was attempted on two occasions, however high Murray River flows resulted in the drying being abandoned. The third attempt in 2012/2013 was successful with an extensive area of the wetland drying. The wetland was refilled by drawing water from the weir pool.

The watering event in 2013/2014 targeted River Red Gum forest, Black Box-chenopod woodland and reed beds.

The 2015/2016 environmental watering event targeted River Red Gum communities, native fish and aquatic vegetation.

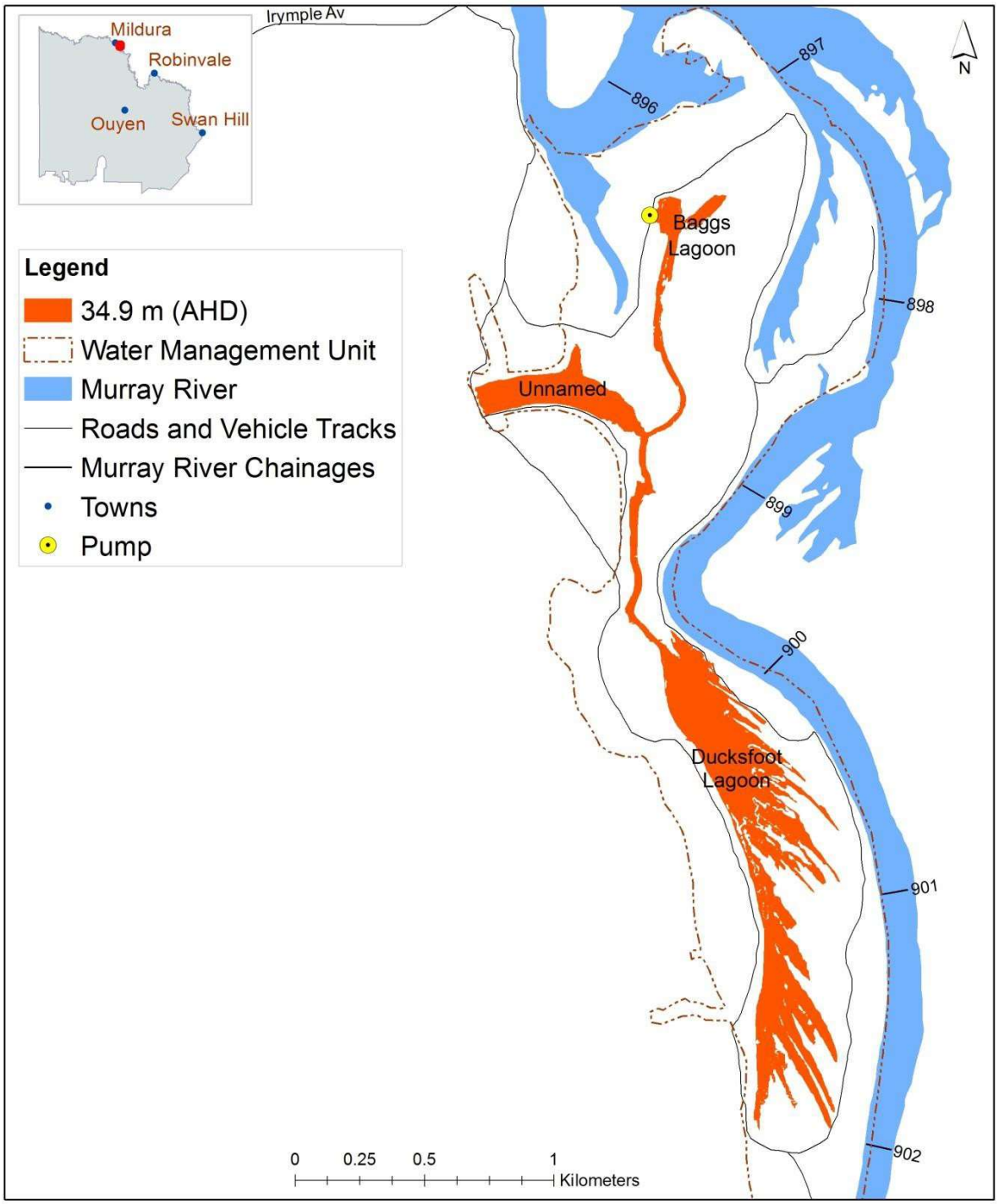



**Figure 7 - Inundation extent of 2015/2016 environmental watering (covering the entire target area)**

# 4 Water dependent values

Wetlands and waterways on the floodplain are a vital component of the landscape. 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.

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

The availability of flora and fauna data for the site is limited. While data from the Victorian Biodiversity Atlas (DELWP, 2016b) and previous site investigations(Ellis, Huntley, Lampard and Wood, 2015b) (Ecological Associates, 2007b) have been referenced, it is recommended that flora and fauna surveys are undertaken at the site to improve knowledge of the site's ecological values.

## 4.1 Environmental values

### Listings and significance

*Fauna*

One hundred and four fauna species have been recorded at Butlers Creek, six of which are introduced. Of special interest and management responsibility are the thirteen water dependent fauna species listed in legislation, agreements or conventions.

Butlers Creek supports species listed under the international agreement Japan-Australia Migratory Bird Agreement (JAMBA); the *Commonwealth Environment Protection and Biodiversity Conservation Act (EPBC Act), Victoria's Flora and Fauna Guarantee Act (FFG Act), and* the Advisory List of Threatened Fauna in Victoria (Table 6).

Despite only a limited number of listed fauna being identified in VBA records, it is fair to assume that more listed species are likely to occur due to the availability of habitat and nearby sightings

**Table 6 - Listed water-dependent fauna at Butlers Creek**

| Common name | Scientific name | Type | International agreements | EPBC threatened fauna status | FFG status | VROT advisory list status |
|---|---|---|---|---|---|---|
| Eastern Great Egret | *Ardea modesta* | B | JAMBA CAMBA | - | Listed | Vulnerable |
| Silver Perch | *Bidyanus bidyanus* | F | - | - | Listed | Vulnerable |
| Brown Treecreeper* (south-eastern ssp.) | *Climacteris picumnus victoriae* | B | - | - | - | Near threatened |
| Un-specked Hardyhead | *Craterocephalus stercusmuscarum fulvus* | F | - | - | Listed | - |
| Little Egret | *Egretta garzetta nigripes* | B | - | - | Listed | Endangered |
| Caspian Tern | *Hydroprogne caspia* | B | JAMBA | - | Listed | Near threatened |
| Golden Perch | *Macquaria ambigua* | F | - | - | - | Near threatened |
| Murray River Rainbowfish | *Melanotaenia fluviatilis* | F | - | | Listed | Vulnerable |
| Pied Cormorant | *Phalacrocorax varius* | B | - | - | - | Near threatened |
| Royal Spoonbill | *Platalea regia* | B | - | - | - | Near threatened |
| Regent Parrot* | *Polytelis anthopeplus monarchoides* | B | - | Vulnerable | Listed | Vulnerable |
| Baillon's Crake | *Porzana pusilla palustris* | B | - | - | Listed | Vulnerable |
| Freshwater Catfish | *Tandanus tandanus* | F | - | - | Listed | Endangered |

Legend:
Lifeform type: Amphibian, Bird, Fish, Invertebrate, Reptile, Mammal
Convention: China-Australia Migratory Bird Agreement (CAMBA); Japan-Australia Migratory Bird Agreement (JAMBA); Republic of Korea Australia Migratory Bird Agreement (ROKAMBA); Convention on the Conservation of Migratory Species of Wild Animals (Bonn Convention)

*Species are included as water dependent due to habitat requirements

Of the nine listed water dependent species at the site, the Regent Parrot (*Polytelis anthopeplus monarchoides*) and the Brown Tree-creeper (*Climacteris picumnus victoriae*) are considered indirectly water dependent due to habitat requirements (e.g. dependent on nesting hollows in riparian trees). The other seven species are directly dependent on water for their food, shelter or breeding requirements.

Two Egret species recorded at Butlers Creek are the Eastern Great Egret, (*Ardea modesta)*, and the Little Egret (*Egretta garzetta nigripes*). Egrets forage in open water and on exposed banks or flats, particularly in areas with aquatic vegetation rather than emergent vegetation (Marchant and Higgins, 1990). They use overhanging trees for nesting, with River Red Gum being their preferred tree. Egrets feed mainly on fish but also consume shrimp, crayfish, frogs and insects (Rogers and Ralph, 2011). Draining of wetlands is the main cause of habitat loss for Egrets in Victoria (DSE, 2001).

Eastern Great Egrets prefer permanent water bodies on floodplains such as billabongs, creeks or pools but will also use the shallow edges of deep lakes, moist grasslands and wetlands (Marchant and Higgins, 1990). They forage by wading in water approximately 30cm in depth as well as from the surface of deeper waters. Flooding is a strong stimulus for breeding for both the Eastern Great Egret

and the Little Egret (Briggs, 1990) and increases breeding success. Both species prefer to nest in live trees over floodwaters, but do not seem to have specific depth requirements.

The Royal Spoonbill (*Platalea regia*) uses both permanent and ephemeral waterbodies in inland areas (Marchant and Higgins, 1990) and prefers freshwater wetlands including swamps with semi-aquatic or emergent vegetation such as rushes. It mainly feeds on fish, crustaceans and insects. Foraging occurs in depths of less than 40cm, where there is a soft substrate, often among aquatic or emergent vegetation. The productivity of several of its food sources is increased when wetlands are inundated following a dry period (Rogers and Ralph, 2011).

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

The Murray-Darling Rainbowfish is a wetland and low-flow opportunist that prefers slow-flowing waters and wetlands where submerged macrophytes are abundant along with other riparian cover, including smaller woody habitat (Allen, Midgley and Allen, 2003; Rogers and Ralph, 2011). They feed on small aquatic and terrestrial insects as well as crustaceans and algae (Lintermans, 2007). The adults can tolerate salinities up to 30,000 $mgL^{-1}$, while juveniles prefer saliniites less than 12,000 $mgL^{-1}$ (Treadwell and Hardwick, 2003).

The Freshwater Catfish (*Tandanus tandanus*) is a benthic species and is usually found near the bottom of lakes and slow-flowing rivers, though it can also use channels and floodplains when inundated (DSE, 2005). Their diet consists of benthic molluscs, crustaceans, insects, snails and small fish. They rely on in stream woody debris for habitat complexity, shelter and increased food supply (Rogers and Ralph, 2011). The introduced fish species Common Carp (*Cyprinus carpio*) is known to negatively impact Catfish populations. The presence of Common Carp is thought to degrade habitat for Freshwater Catfish by increasing turbidity, nutrient and reducing aquatic vegetation (DSE, 2005). It can tolerate salinities up to 17,700 $mgL^{-1}$ (Treadwell and Hardwick, 2003).

Golden Perch (*Macquaria ambigua*) are usually found in warm, turbid and slow flowing waters in lowland rivers, including backwaters, billabongs and anabranches (Treadwell and Hardwick, 2003). Fallen logs and woody debris are important habitat for the Golden Perch (Rogers and Ralph, 2011). Large, deep waterholes in dryland rivers are important refugia during dry periods (Balcombe and Humphries, 2006). Golden Perch can tolerate salinities up to 33,000 $mgL^{-1}$, but not low dissolved oxygen (King, Humphries and Lake, 2003). Golden Perch undertake significant migration both upstream and downstream in spring; strong recruitment is linked to rising flows in spring, accompanied by rising water temperatures and extended photoperiod. Major flooding enhances spawning success (King, Tonkin and Mahoney, 2009).

Silver Perch (*Bidyanus bidyanus*) prefer main channel and large anabranches of lowland rivers, though will occasionally move into small anabranches and floodplain lakes during large floods (Treadwell and Hardwick, 2003). They favour reaches that provide cover such as woody debris and littoral vegetation (Rogers and Ralph, 2011) and are omnivorous, feeding on aquatic plants, snails, shrimps and aquatic insect larvae (Lintermans, 2007). Silver Perch tend to spawn and recruit following increased flow. Major spawning events follow floodplain inundation (Young, Scott, Cuddy and Rennie, 2003). The species but does not cope well with low dissolved oxygen or high salinity (King, Humphries and Lake, 2003).

Un-specked Hardyhead (*Craterocephalus stercusmuscarum fulvus*) prefer the margins of slow-flowing rivers, back waters and billabongs, usually in shallow vegetated areas with sandy or muddy substrates (Allen, Midgley and Allen, 2003). The Un-specked Hardyhead will move onto the floodplain during rising flows (Lyon, Stuart, Ramsey and O'Mahony, 2010). Juveniles are found mostly in billabong habitats and the species is a wetland opportunist that will mainly spawn and recruit in anabranches, billabongs and floodplain wetlands, though they will also do so in the main channel (Young et al., 2003). Their diet mainly small insects such as mosquito larvae and small crustaceans (Lintermans, 2007). Un-specked Hardyhead can survive temperatures of 9.3 – 36$^{0}$C and salinities up to 43,000mgL$^{-1}$(Treadwell and Hardwick, 2003).

Growling Grass Frogs (*Litoria raniformis*) have been recorded at the adjacent Kings Billabong and are likely to use habitat within the Butlers Creek target area. The species is listed under the EPBC Act as Vulnerable and the FFG Act as Threatened. It is usually found in among vegetation within or at the edges of permanent or ephemeral wetlands or slow flowing rivers and streams. In disturbed areas it can be found in farm dams and irrigation channels (Pyke, 2002). The wider landscape mosaic also seems to be critical.

*Vegetation communities*

Butlers Creek is positioned at the north-west end of the Robinvale Plains bioregion which contains the floodplains of the Murray River, close to the boundary with the Murray Mallee bioregion which stretches inland.

Five Ecological Vegetation Classes (EVCs) (plus Bare Rock/ground) are modelled as present within the target area. Table 7 provides a list of these EVCs, along with their bioregional conservation status, Figure 8 displays the spatial arrangement of the EVCs, and Appendix 2 provides detailed descriptions of the EVCs.

**Table 7 - Ecological Vegetation Classes modelled as present within the Butlers Creek target area**

| EVC no. | EVC name | Area modelled as present within target area (ha) | Bioregional conservation status |
|---|---|---|---|
| | Bare rock/ground | 16.81 | n/a |
| 106 | Grassy Riverine Forest | 0.12 | Depleted |
| 103 | Riverine Chenopod Woodland | 0.34 | Depleted |
| 808 | Lignum Shrubland | 13.40 | Least concern |
| 813 | Intermittent Swampy Woodland | 12.19 | Depleted |
| 821 | Tall Marsh | 2.79 | Depleted |

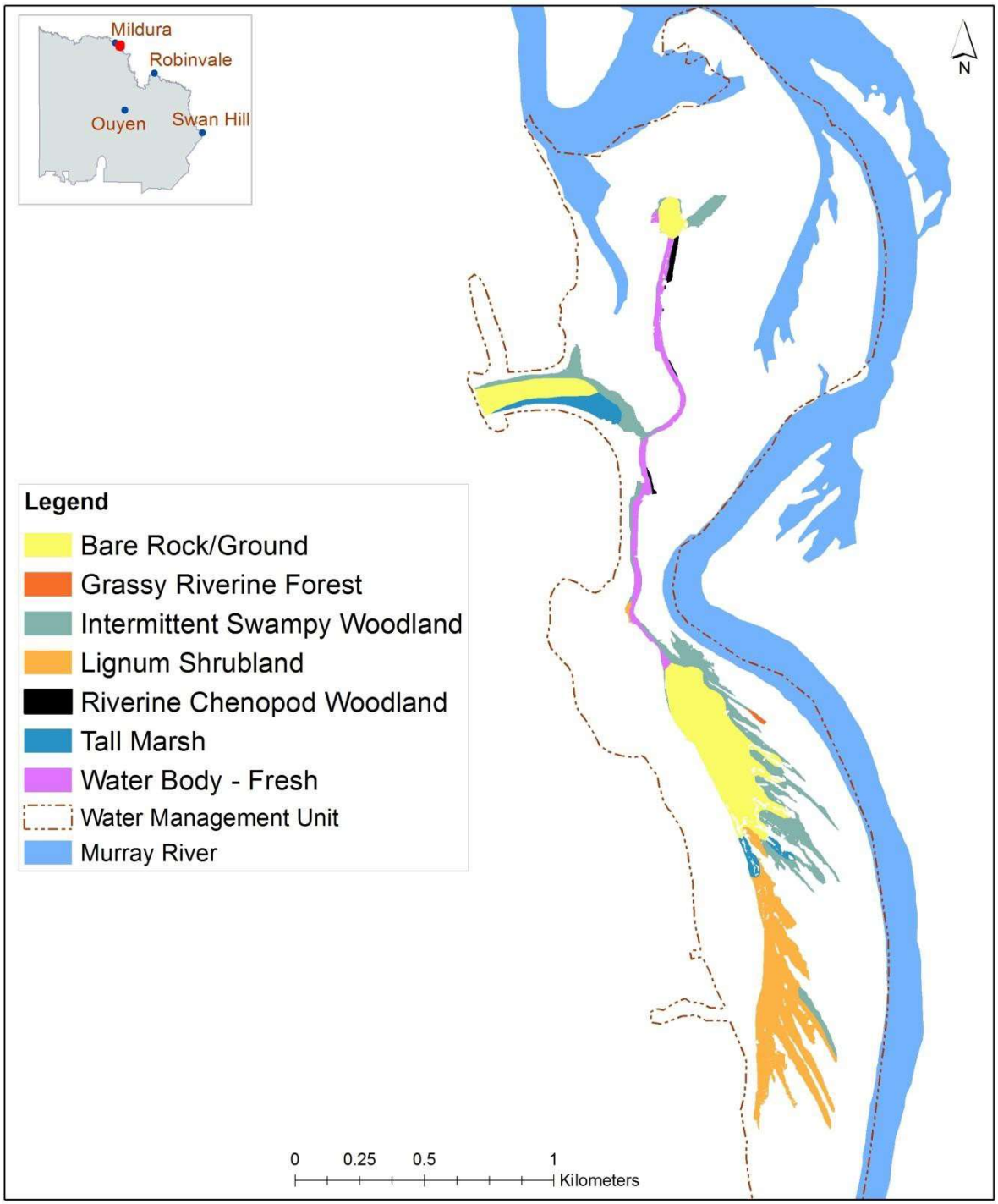



**Figure 8 – Ecological Vegetation Classes present in the Butlers Creek target area**

**Figure 9 – Baggs Lagoon is surrounded by Intermittent Swampy Woodland and Riverine Chenopod Woodland.**

Baggs Lagoon is almost permanently inundated and supports submerged and emergent aquatic macrophytes. The surrounding EVCs for Baggs Lagoon and Butlers Creek are Riverine Chenopod Woodland and Intermittent Swampy Woodland (Figure 9, Figure 10 and Figure 11).

Riverine Chenopod Woodland has a diverse shrubby and grassy understorey and is subject to only infrequent shallow flooding during major events. Intermittent Swampy Woodland has an overstorey of River Red Gums and or Black Box and an understorey of sedges and shrubs, including Lignum.

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

Black Box provides essential habitat and foraging opportunities for a range of species including mammals and reptiles and supports a high proportion of ground foraging and hollow-nesting birds. Black Box can tolerate long periods without inundation (Roberts and Marston, 2011), however recruitment and establishment is linked to the elevated and continued soil moisture associated with flood events. Under extended periods of dry conditions Black Box is likely to decline and eventually die (Ecological Associates, 2007a).

**Figure 10 – Butlers Creek is fringed by Riverine Chenopod Woodland and Intermittent Swampy Woodland.**

**Figure 11 – Intermittent Swampy Woodland is present between Ducksfoot Lagoon and the Murray River.**

Lignum Shrublands are located in floodplain depressions that retain water following flood events . Lignum Shrubland is dominated by Lignum and chenopod shrubs with a ground layer of grasses and herbs that are tolerant of, or able to survive, both periods of inundation and dry.

When flooded, areas of Lignum can provide nesting habitat for platform building birds as well as productive fish habitat (Ecological Associates, 2006b). Tangled Lignum (*Duma florulenta*) has particular ecological value as waterbird breeding habitat making it especially significant. Wetland birds that breed over water, use flooded Lignum Shrubland (Ecological Associates, 2007a) for nesting and other waterbirds use Lignum for nesting (Rogers and Ralph, 2011).

Tall marsh is a wetland EVC dominated by tall emergent rushes, sedges and or reeds. It often has low plant diversity. It is dominated by a few highly competitive species that are tolerant of prolonged inundation to depths less than 1.5 m, but not sustained total immersion. It is present at the shallow ends of Ducksfoot Lagoon (Figure 12).

**Figure 12 - Ducksfoot Lagoon with extensive areas of reed beds**

*Flora*

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

**Table 8 - Listed flora recorded at Butlers Creek**

| Common name | Scientific name | Inundation dependent | FFG status | VROT advisory list status |
|---|---|---|---|---|
| Blue Burr-daisy | *Calotis cuneifolia* | unknown | - | Rare |
| Native Couch | *Cynodon dactylon* var. *pulchellus* | yes | - | Poorly known |
| Riverine Flax-lily | *Dianella porracea* | unknown | - | Vulnerable |
| Spreading Emu-bush | *Eremophila divaricata* subsp. *divaricata* | yes | - | Rare |
| Spotted Emu-bush | *Eremophila maculata* subsp. *maculata* | yes | Nominated | Rare |
| Narrow-leaf Emu-bush | *Eremophila sturtii* | no | Listed | Endangered |
| Tall Nut-heads | *Ethuliopsis cunninghamii* | yes | - | Vulnerable |
| Warty Peppercress | *Lepidium papillosum* | yes | - | Poorly known |
| Native Peppercress | *Lepidium pseudohyssopifolium* | yes | - | Poorly known |

| | | | | |
|---|---|---|---|---|
| Smooth Minuria | *Minuria integerrima* | yes | - | Rare |

Source: (DEPI, 2014a; DELWP, 2015; National Herbarium of New South Wales, n.d.; Atlas of Living Australia, n.d.; Bush Heritage Australia, 2016)

### Other fauna

*Waterbirds*

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

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

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

| Waterbird Group | Food Resource | Habitat Use |
|---|---|---|
| Dabbling and Diving Ducks (e.g. Grey Teal, Pacific Black Duck, Black Swan, Eurasian Coot) | Generalists; plankton, small invertebrates, plant material | Shallow Water (Dabblers) |
| Grazing Waterfowl (e.g. Australian Wood Duck) | Plant material, seeds, invertebrates | Shallow Water, littoral zone |
| Fish Eaters (e.g. Grebes, Pelican, Cormorants, Darters Egrets, Heron, Tern) | Fish | Open and deep water |
| Small Waders (e.g. Black-tailed Native Hen, Purple Swamphen, Masked Lapwing, Black-fronted Dotterel) | Small invertebrates, seeds | Littoral zone, mudflats |
| Large Waders (e.g. Spoonbill, Ibis) | Macroinvertebrates, fish, amphibians | Littoral zone |
| Shoreline Foragers (e.g. Lapwings, Hens) | Plant material, seeds, invertebrates, | Littoral zone, mudflats |

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

**Figure 13 - Ducksfoot Lagoon provides habitat for piscivorous waterbirds.**

*Fish*

As well as the listed species, a range of other fish species have been recently recorded within the target area including Western Carp Gudgeon (*Hypseleotris klunzingeri*), Flathead Gudgeon (*Philypnodon grandiceps*), Bony Herring (*Nematalosa erebi*), Australian Smelt (*Retropinna semoni*), and Dwarf Flathead Gudgeon (*Philypnodon macrostomus*) (Ellis et al., 2015b). The introduced species Goldfish (*Carassius auratus*), Carp, Oriental Weatherloach (*Misgurnus anguillicaudatus*), and Eastern Gambusia (*Gambusia holbrooki*) have also recently been found within the target area.

**Figure 14 - Butlers Creek supports a wide range of fish species.**

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

The target area contains one wetland type under the 1994 classification, Permanent Open Freshwater. Permanent Open Freshwater has suffered a slight loss across the state (-6%) and has gained area in Mallee CMA (+5%), possibly due to raised weir levels along the Murray River permanently inundating wetlands that would previously have been only inundated seasonally. Within the Murray Scroll Belt bioregion it has reduced in extent (-1%) (Table 10).

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

| Corrick category | Wetland name | Total area (ha) | Percentage change in wetland area from 1788 to 1994 | | |
|---|---|---|---|---|---|
| | | | Change in Victoria | Change in Mallee CMA | Change in Robinvale Plains bioregion |
| Permanent Open Freshwater | Ducksfoot Lagoon | 16.4 | -6% | +5% | -1% |
| | Baggs Lagoon | 1.2 | | | |

Victoria's wetland classification was updated in 2013 and is now based on the Australian National Aquatic Ecosystem Classification Framework. The 'Wetland Current' layer (Full title: Victorian Wetland Environments and Extent - up to 2013) lists Ducksfoot Lagoon and Baggs Lagoon as Permanent Freshwater Lakes.

### Ecosystem functions

Floodplain wetlands perform important functions necessary to maintain the hydrological, physical and ecological health of river systems.

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

*Creation and maintenance of vital habitats and populations*

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

The slow-flowing waters, in-stream woody habitat and variable water levels of Butlers Creek will support Freshwater Catfish. This permanent waterway will act as refugia for frogs, native fish and waterbirds during periods of extended drought in an arid landscape.

Seasonal inundation of littoral and riparian areas along Butlers Creek will encourage a diversity of emergent, submerged and floating macrophytes and fringing vegetation, providing shelter, feeding and spawning areas for the Growling Grass Frog (Clemann and Gillespie, 2012).

Areas of deeper, permanent water with quality in-stream habitat will support a range of fish species and provide a reliable food source for piscivorous waterbirds.

*Connections across floodplains, adjacent wetlands and billabongs (lateral)*

Water levels that engage flood channels and inundate wetlands and floodplain surfaces will promote nutrient and carbon cycling and return organic material to the river for further processing (Robertston, Bacon and Heagney, 2001).

The waterbird groups also access a variety of habitat types such as mud flats and shallow aquatic vegetation which only become available following inundation.

*Diversity of habitat for feeding, breeding and nursery*

Seasonal fluctuations in water levels in the wetlands increase the availability of specific habitat niches for feeding, breeding and nursery areas. The permanent and semi-permanent water bodies will provide a source of food, refuge from predators and nesting sites and materials for waterbirds (Kingsford and Norman, 2002).

Wetland filling and water recession will promote a broad band of sedges, rushes and semi-aquatic forbs surrounding wetlands. Areas of deeper, permanent water will support submerged aquatic macrophytes. This will promote high levels of aquatic productivity and physical habitat for frogs, fish, and waterbirds. Flooded Lignum Shrubland areas around Ducksfoot Lagoon will provide nesting areas for large waders to reproduce.

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

Drying of wetlands, particularly during summer and autumn, exposes sediments and facilitates decomposition and processing of organic matter. The microbial decay of plant material is an important route for energy and nutrients to enter the riverine food chain (Young, 2001). During dry periods, organic matter such as leaf litter is slowly decomposed by bacteria, releasing carbon and nutrients which accumulate in the soil.

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

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

## 4.2 Social values

### Cultural value

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

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

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

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

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

### Cultural heritage

Butlers Creek and the adjacent King's Billabong are areas of Cultural Heritage sensitivity and hold rich indigenous cultural values and a large number of Aboriginal places and objects such as middens, scar trees, artefact scatters and burial sites (Parks Victoria, 2006). The Nyeri Nyeri and Latji Latji people were the indigenous community at the time of settlement (Parks Victoria, 2006). Currently there is no Registered Aboriginal Party for the area however there is an application before the Victorian Aboriginal Heritage Council for the area by the First Peoples of the Millewa-Mallee Aboriginal Corporation (Department of Premier and Cabinet, 2016).

The area is strongly associated with the history and development of the local irrigation industry and the reserve was logged to provide timber for steam driven pumps and paddleboats (Parks Victoria, 2006).

## 4.3 Recreation

Butlers Creek is close to Mildura and its easy accessibility, permanent water, diversity of scenery and access to the Murray helps to make it popular for walking (a range of walking trails are provided), picnicking (several designated picnic areas, fire places and tables are provided), birdwatching, fishing and four-wheel driving.

Local community has been participating in citizen science projects at Butlers Creek and Ducks foot Lagoon to survey for native fauna in the park. In 2019, citizen science projects included bat, bird and frog monitoring. Five species of bats were surveyed by a local scout group, these bats were not previously listed in the EWMP and have been added to Appendix 1 – Fauna list. Five species of frogs were surveyed by a local resident at Ducks foot Lagoon, three of these species were not listed in the EWMP have been added to Appendix 1 – Fauna list. A teenage boy has been monitoring Ducks foot lagoon for birds over the last two years. His survey work has revealed an additional twelve birds that previously were not listed in the EWMP are using the lagoon, these have also been added to Appendix 1.

A local recreational fishing group, Sunraysia Ozfish has been undertaking works at Butlers creek to improve the habitat for native fish. Works undertaken in 2019 include vegetation monitoring along the banks of the creek, habitat mapping the creek bed and the addition of habitat via installation of logs and 'fish hotels'.


*Revegetation along Butlers Creek*

*Fish Hotels in Butlers Creek*

## 4.4 Economic values

The natural beauty of Butlers Creek and the adjacent Kings Billabong attracts both locals and tourists. Butlers Creek is close to the town of Irymple and only twelve kilometres from the rural centre Mildura. Surrounding land uses include irrigated horticulture such as orchards and vineyards/wineries.

## 4.5 Significance

Butlers Creek provides the preferred habitat for the Endangered Freshwater Catfish and the Vulnerable Growling Grass Frog. Breeding of large wading birds could be supported in the flooded Lignum vegetation communities within Ducksfoot Lagoon, and large numbers of piscivorous water birds will be supported by high levels of aquatic productivity and the abundant fish community. Butlers Creek is a high profile site for environmental watering with high numbers of visitors to the Kings Billabong Park and the close proximity to Mildura.

# 6 Ecological condition and threats

## 6.1 Current condition

The condition of Ducksfoot Lagoon and Baggs Lagoon was assessed in 2010 using the Index of Wetland Condition (IWC). The IWC defines wetland condition as the state of the biological, physical, and chemical components of the wetland ecosystem and their interactions. The IWC has five sub-indices based on the catchment of the wetland and its fundamental characteristics: physical form, hydrology, water properties, soils and biota. Each sub-index is given a score between 0 and 20 based on the assessment of a number of measures. The overall IWC score is not a simple summation of the sub index scores. A formula is used that weights each sub index according to the contribution it makes to the overall condition of the wetland. The wetland hydrology sub index for example contributes more to the overall score than the soils sub index.

Ducksfoot Lagoon scored well on all sub-indices except hydrology and water properties. Baggs Lagoon scored well on physical form, soils and biota, moderately on wetland catchment and very poorly on hydrology (Table 11, Figure 15, Figure 16 and Figure 17).

**Table 11 - Butlers Creek Index of Wetland Condition results (2010)**

| IWC sub-index | Score /20 | Category |
|---|---|---|
| **Ducksfoot Lagoon** | | |
| Wetland catchment | 20 | Excellent |
| Physical form | 20 | Excellent |
| Hydrology | 0 | Very poor |
| Water properties | 10 | Moderate |
| Soils | 19 | Excellent |
| Biota | 16 | Moderate |
| Overall IWC score | 6 | Moderate |
| **Baggs Lagoon** | | |
| **Wetland catchment** | 13 | Moderate |
| Physical form | 20 | Excellent |
| Hydrology | 0 | Very poor |
| Water properties | 17 | Good |
| Soils | 19 | Excellent |
| Biota | 17 | Good |
| **Overall IWC score** | 7 | Good |

Source: (DEPI, 2014b)

**Figure 15 - Ducksfoot Lagoon provides areas of macrophyte beds, structural woody habitat and open water (February 2016).**

**Figure 16 - Baggs Lagoon showing extensive areas of submerged and emergent macrophytes (Source IWC 2010)**

**Figure 17 - In 2016 Baggs Lagoon showed evidence of River Red Gum recruitment and areas of submerged and emergent macrophytes (February 2016).**

Butlers Creek was assessed in 2010 using the Index of Stream Condition (ISC). The Index of Stream Condition (ISC) is a composite indicator of river condition (similar to the IWC) that assesses 23 indicators across 5 major sub-indexes: hydrology, physical form, streamside zone, water quality and aquatic life. Butlers Creek was assessed using the ISC in 2010 and was found to be in a very poor condition.

Only three of the five sub-indices were measured, hydrology (1/10), physical form where it scored well on bank condition but poorly on the presence of artificial barriers and in-stream large wood (5/10) and streamside zone (6/10).

## 6.2 Condition trajectory

The installation of the regulators and implementation of a drying phase to control carp numbers, followed by appropriate environmental watering has significantly improved the condition at Butlers Creek. Implementing an appropriate seasonal watering regime will continue to improve condition.

## 6.3 Water related threats

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

### Invasive fauna

Before the wetland was regulated and dried out, Carp were prevalent in the Butlers Creek target area. Carp have been found to contribute to the loss of aquatic vegetation and increased turbidity, resulting in loss of habitat for waterfowl (Purdey and Loyn, 2008) and native fish species. This species also competes with the native fish for habitat and food (Mallee CMA, 2003). Carp degrade Freshwater Catfish habitat by disturbing nests on the wetland bed and increasing turbidity (Lake, 1967).

Evidence of feral pigs was visible during site investigations in February 2016, with pugging and vegetation damage evident near Baggs Lagoon (Figure 18). Feral pigs pug and dig the wetland soil, destroy macrophyte beds, increase nutrient levels and reduce water clarity. Feral fox and cat control has also been undertaken at the site in the past and domestic dogs and cats have been noted as a threat to native fauna at the site (Parks Victoria, 2006).

**Figure 18 – The impact of feral pigs alongside wetlands at Butlers Creek.**

### Changed water regime

Baggs Lagoon, Ducksfoot Lagoon and Butlers Creek all scored poorly on the hydrology sub-index of the IWC and ISC. The hydrology sub-index of the IWC takes into account the impacts of regulation of the primary water source of the wetland (Murray River), other activities which may impact the wetlands water regime, impacts to seasonality, duration and frequency of the water regime and the severity of the effects of these activities. The ISC hydrology sub-index for Butlers Creek was assessed using a flow stress ranking procedure, a numerical modelling process using water flow gauge information from across Victoria. It was calculated from information on high flow, low flow, zero flow, seasonality and variability (DEPI, 2014c). The installation of the regulators means that these threats will be reduced through environmental water management.

# 7 Management objectives

## 7.1 Management goal

The management goal for the Butlers Creek EWMP is:

“The Butlers Creek target area to be permanent wetlands with seasonal variation in water levels that will support the populations of Growling Grass Frog and Freshwater Catfish and support key habitat requirements of piscivorous and large wading birds.”

## 7.2 Ecological objectives

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

The ecological objectives for Butlers Creek are:

*All water areas*

- Self-sustaining population of Growling Grass Frogs
- Self-sustaining population of Freshwater Catfish
- Maintain high levels of aquatic productivity
- Feeding by piscivorous waterbirds

*Ducksfoot and Baggs Lagoon*

- Foraging and breeding by large wading birds

**Table 12 - Ecological objectives for Butlers Creek**

| Ecological objective | Justification | Wetland area |
|---|---|---|
| Self-sustaining population of Growling Grass Frogs | Growling Grass Frog prefer sites that have a large proportion of vegetation that is emergent, submerged and floating (Clemann and Gillespie, 2012) as seen within the Butlers Creek target area. Growling Grass Frog is listed as Vulnerable. | All |
| Self-sustaining population of Freshwater Catfish | Butlers Creek supports the preferred habitat of the Freshwater Catfish which is listed as endangered. | All |
| Maintain high levels of aquatic productivity | Alternating periods of inundation and exposure accelerate the decomposition of organic matter and increase availability of organic carbon and mineral nutrients in the wetland food web. | All |
| Feeding by piscivorous waterbirds | Semi-permanent or permanent waterbodies are generally more favoured by the fish-eating waterbird species such as Cormorants, Darter and Australian Pelican (Scott, 1997) | All |
| Foraging, nesting and recruitment by large wading birds | Flooded Lignum communities provide important nesting and foraging habitat for large wading birds found within the target area. | Ducksfoot |

## 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 described below.

Butlers Creek provides the preferred habitat for Freshwater Catfish, consisting of undercut root trusses, fallen logs and small woody material (Rogers and Ralph, 2011), in slow-flowing rivers, or inundated secondary channels. Connection of the channels and floodplain wetlands provide additional habitat complexity for Freshwater Catfish. Freshwater Catfish are resident fish species that build nests in November before spawning. Freshwater Catfish will abandon their nests if water levels drop and they will not spawn if flows changes throughout summer (Lake, 1967).

Growling Grass Frogs prefer large continuous areas containing a range of regularly flooded permanent and ephemeral waterbodies with nearby refugia (Clemann and Gillespie, 2012). During the winter months individuals may shelter under cover close to the water such as rocks, logs and vegetation (Pyke, 2002). Breeding is triggered by flooding of wetlands and floodplains during spring and summer (Clemann and Gillespie, 2012).

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

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).

Large waders such as Great Egret and Little Egret can take about 3.5 months to build nests, lay and incubate their eggs and to fledge their young. For a flood in spring and early summer, a 2-3 month time lag is also required and hence minimum duration of flooding which is required for successful breeding is about 5-7 months. (Scott, 1997).

Egrets and other large waders may only breed successfully if water surrounds their nest sites. If the water level drops and the wetlands starts to dry up before the young birds fledge, there is a great risk that the adults will abandon the nests. (Scott, 1997).

**Table 13 - Hydrological objectives for Butlers Creek**

| Level | Zone | Freq | Duration | Timing |
|---|---|---|---|---|
| <33.5 | Wetland bed (drying phase) | As required | | |
| 33.9 | Aquatic refuge | 10:10 | 12 months | At all times |
| 33.9 | Macrophyte zone | 1:1 | 4-6 months | Late winter / early summer |
| 34 | Grassy Woodland zone | 1:2 | 2-4 months | Late winter / early summer |
| 34.9 | Lignum wetlands | 1:3 | 2-4 months | Late winter / early summer |

## 7.4 Watering regime

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

The optimal watering regime is described below. Due to the inter-annual variability of these estimates (particularly the climatic conditions), determination of the predicted volume requirements in any given year will need to be undertaken by the environmental water manager when watering is planned.

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

### Optimal watering regime

Butlers Creek, Baggs Lagoon and Ducksfoot Lagoon are to be managed as a permanently inundated water area with seasonal variations in water level.

Fill wetlands to 34.9m AHD every spring/summer allowing natural drawdown of the level during autumn. Ensure that permanent open water habitat is maintained by ensuring that water levels do not fall below 33.9m AHD by opening the regulator gate. Every three years fill wetland to 34.9m AHD and maintain this level for seven months to facilitate waterbird breeding and flushing of sediment. Top up as required.

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

# 8 Managing risks to achieving objectives

| Threat | Likelihood | Consequence | Risk – H, M, L (likelihood x consequence) | Management measure | Residual risk |
|---|---|---|---|---|---|
| Failure to meet ecological objectives | Possible | High | H | Monitoring program in place. Adaptive approach. | L |
| Species, communities or ecological functions have been overlooked in water regime due to lack of data | Possible | High | H | Review ecological survey results and update objectives if significant gaps are found. | L |
| Inundation duration too long or too short | Possible | High | H | Monitoring program in place. Adaptive approach as additional baseline and monitoring outcome data is available. | L |
| Environmental watering causes water quality issues (i.e. blackwater, Acid Sulphate Soil etc.) | Possible | Moderate | M | Observe water quality through watering season and manage accordingly. | L |
| Water regime significantly enhances habitat for Carp | Likely | Moderate | M | Monitoring of Carp. Review of inlet and pumping equipment to screen Carp. Drying of wetland. | L |
| Criminal damage or theft of water delivery infrastructure | Possible | Moderate | M | Utilise appropriate security devices on equipment and proactively engage with the community prior to watering event to gain support for the program. | L |
| Damage to infrastructure, leading to loss of water from target area | Likely | Moderate | M | Appropriate engagement and site management in place. Regular monitoring and staff presence during watering events. | L |

| Threat | Likelihood | Consequence | Risk – H, M, L (likelihood x consequence) | Management measure | Residual risk |
|---|---|---|---|---|---|
| Maintenance required to delivery infrastructure (pump/channel etc.) during proposed watering event | Likely | High | VH | Include maintenance of channel on annual inspection checklist. Ensure pump contractors are appropriately qualified and have appropriate quality assurance processes in place. | L |
| Environmental releases flood access tracks | Possible | Minor | M | Track works associated with regulator and stop bank construction undertaken with appropriate planning. Provide signage about watering event. Engagement plan to be implemented. | L |
| Monitoring program is unable to detect improvement in short to medium term | Possible | High | H | Engagement with key stakeholders confirming expected outcomes, timeframes and assumptions. | L |
| Damage to cultural heritage sites through construction of temporary infrastructure and equipment | Possible | High | H | Site risk assessments undertaken and mitigations in place prior to any works occurring. Cultural Heritage Management Plans in place. | L |

# 9 Environmental water delivery infrastructure

## 9.1 Constraints

The recommended watering regime can be implemented with the existing infrastructure in place. However, the regulator on Butlers Creek cannot be operated to full supply level (70cm above weir pool operating level) as access tracks are inundated and water returns to the river. An assessment was undertaken to investigate options to raise the track and it was deemed unfeasible due to the extent of vegetation removal required to achieve the outcome.

## 9.2 Infrastructure or complementary works recommendations

There is no infrastructure or complimentary works recommendations for Butlers Creek.

# 11 Demonstrating outcomes

## 11.1 Monitoring priorities at the site

The following priorities for monitoring have been identified for the Butlers Creek target area:

- ISC and IWC monitoring should be undertaken at Baggs Lagoon, Ducksfoot Lagoon and Butlers Creek on a five-yearly basis.
- Monitoring of Freshwater Catfish and Growling Grass Frog populations to ensure recruitment is occurring.
- Monitoring of waterbird diversity, abundance and breeding within the target area should occur during each of the watering events.
- Monitor extent and length of inundation of Intermittent Swampy Woodland and Lignum Shrubland at Ducksfoot to ensure that there is enough time for target large wading bird species to recruit.
- Telemetry on depth gauges should be used to continuously monitor depth through the wetting and drying phases of the water regime.
- Photo point monitoring of tree health within the woodlands should be undertaken.
- Monitor Carp populations within waterbodies.

# 12 Consultation

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

**Table 14 - Consultation for development of Butlers Creek EWMP**

| Meeting Date | Stakeholders | Details |
|---|---|---|
| May 2016 | Friends of Kings Billabong | Presentation of plan.<br><br>Group would like a copy of the final EWMP to help with the production information signs currently being developed. |
| June 2016 | First peoples of the Millewa - Mallee Aboriginal Corporation | Presentation of plan. |
| May 2016 | Parks Victoria | Presentation of plan. |
| June 2016 | Department of Environment, Land, Water and Planning | Presentation of plan |
| May 2016 | Lower Murray Water | Presentation of plan. |
| June 2016 | Mildura BirdLife | Presentation of plan. |
| June 2016 | Friends of Merbein Common | Presentation of plan. |

# 13 Knowledge gaps and recommendations

There are no significant knowledge gaps.

# References


Allen, G., Midgley, S. and Allen, M., 2003. *Field Guide to Freshwater Fishes of Australia*. 2nd ed. CSIRO Publishing.

Atlas of Living Australia, n.d. *Atlas of Living Australia*. [online] Available at: <http://www.ala.org.au/> [Accessed 2 Mar. 2016].

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

Balcombe, S.R. and Humphries, P., 2006. Diet of the western carp gudgeon (Hypseleotris klunzingeri Ogilby) in an Australian floodplain lake: the role of water level stability. *Journal of Fish Biology*, 68(5), pp.1484–1493.

Baldwin, D., 2008. *Assessment of sulfidic sediments in Lake Hawthorn, Cowra Rooks and Butlers Creek*. Murray-Darling Freshwater Research Centre.

Bancroft, T., Gawlick, D. and Rutchey, K., 2002. Distribution of wading birds relative to vegetation and water depths in the northern Everglades of Florida, USA. *Journal of Waterbird Society*, 25(3), pp.265–391.

Briggs, S.V., 1990. Waterbirds. In: *The Murray*. Canberra, ACT: Murray-Darling Basin Commission, pp.337–344.

Bush Heritage Australia, 2016. *Neds Corner Station - Herbarium*. [online] Available at: <http://www.nedscorner.com.au/herbarium.php> [Accessed 2 Mar. 2016].

Chapman, D., Baldwin, D. and Ellis, I., 2010. *Assessment of Sulfidic Sediments in four Kings Billabong Wetlands*. Murray-Darling Freshwater Reseach Centre.

Clemann, N. and Gillespie, G.R., 2012. *National Recovery Plan for the Southern Bell Frog Litoria raniformis*. [online] Department of Sustainability and Environment, Melbourne. Available at: <https://www.environment.gov.au/system/files/resources/9b960bf4-cc03-4ee9-b1a4-b80494662f64/files/litoria-raniformis.pdf> [Accessed 3 Mar. 2016].

Dalton, K., 1990. *Managing our River Red Gums*. Sydney: Soil Conservation Service of New South Wales.

DELWP, 2015. *Flora and Fauna Guarantee Act 1988 Threatened List*. Department of Environment, Land, Water and Planning.

DELWP, 2016a. *Biodiversity Interactive Map*. [online] Available at: <http://mapshare2.dse.vic.gov.au/MapShare2EXT/imf.jsp?site=bim> [Accessed 1 Mar. 2016].

DELWP, 2016b. *Victorian Biodiversity Atlas*. [online] Available at: <https://vba.dse.vic.gov.au/vba/login.jsp> [Accessed 7 Feb. 2016].

Department of Premier and Cabinet, 2016. *Statewide Registered Aboriginal Parties and Registered Aboriginal Party Applications before the Victorian Aboriginal Heritage Council*. Available at: <http://www.dpc.vic.gov.au/index.php/aboriginal-affairs/registered-aboriginal-parties>.

DEPI, 2014a. *Advisory list of rare or threatened plants in Victoria - 2014*. Department of Environment and Primary Industries.

DEPI, 2014b. *Index of Condition System*. [online] Available at: <http://ics.water.vic.gov.au/ics/> [Accessed 9 Mar. 2016].

DEPI, 2014c. *ISC Hydrology sub-index factsheet*. East Melbourne, Victoria: Department of Environment and Primary Industries.

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

DSE, 2001. *Action Statement; Great Egret Ardea alba, Intermediate Egret Ardea intermedia, Little Egret Egretta garzetta*. East Melbourne, Victoria: Department of Sustainability and Environment.

DSE, 2005. *Freshwater Catfish Action Statement*. East Melbourne, Victoria: Department of Sustainability and Environment.

DSE, 2013. *EVC Bioregion Benchmark for Vegetation Quality Assessment. Murray Scroll Belt Bioregion*. East Melbourne, Victoria: Department of Environment and Sustainability.

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

Ecological Associates, 2006b. *Investigation of Water Management Options for the Murray River - Nyah to Robinvale: Final*

*Report*. Mildura, Victoria: Report prepared for Mallee Catchment Management Authority.

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

Ecological Associates, 2007b. *Investigation of Water Management Options for the River Murray – Robinvale to Wallpolla Island: Final Report*. Mildura, Victoria: Report prepared for Mallee Catchment Management Authority.

Ecological Associates, 2013. *Locks 8 and 9 Weir Pool Manipulation Optimisation Plan- Analysis Report*. Buronga: Ecological Associates.

Ellis, I. and Campbell, C., 2013. *Kings Billabong Fish and Aquatic Vegetation Monitoring 2011-2012: Summary of Results*. Murray-Darling Freshwater Reseach Centre.

Ellis, I., Huntley, S., Lampard, B. and Wood, D., 2015a. *Fish movement in response to a managed drawdown of Butlers Creek and Psyche Lagoon, Kings Billabong Nature Reserve, Victoria (winter 2014)*. Murray-Darling Freshwater Reseach Centre.

Ellis, I., Huntley, S., Lampard, B. and Wood, D., 2015b. *Fish movement in response to a managed drawdown of Butlers Creek and Psyche Lagoon, Kings Billabong Nature Reserve, Victoria (winter 2014)*. Final report prepared for the Mallee CMA by the Murray-Darling Freshwater Research Centre, p.31.

Gippel, C.J., 2014. *Spells analysis of modelled flow for the River Murray from Swan Hill to the South Australian Border*. Stockton: Fluvial Systems Pty Ltd, Stockton. Mallee CMA, November.

Haig, S., Mehlman, D. and Oring, L., 1998. Avian movements and wetland connectivity in landscape conservation. *Conservation Biology*, 12(4), pp.749–758.

Johns, C. and et al., 2009. *Literature review and experiemental design to address retaining floodwater on floodplains and flow enhancement hypotheses relevant to native tree species*. Wodonga: Murray-Darling Freshwater Reseach Centre.

King, A.J., Humphries, P. and Lake, P.S., 2003. Fish recruitment on floodplains: the roles of patterns of flooding and life history characteristics. *Canadian Journal of Fisheries and Aquatic Sciences*, 60(7), pp.773–786.

King, A., Tonkin, Z. and Mahoney, J., 2009. Environmental flow enhances native fish spawing and recruitment in the Murray River, Australia. *River Research and Applications*, 25, pp.1205 – 1218.

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

Lake, J.., 1967. Rearing experiments with five species of Australian freshwater fishes. 1. Inducement to spawning. *Australian Journal of Marine and Freshwater Research*, 18, pp.137–153.

Lintermans, M., 2007. *Fishes of the Murray–Darling Basin - An introductory guide*. [online] Murray-Darling Basin Authority. Available at: <http://www.mdba.gov.au/media-pubs/publications/fishes-murray-darling-basin-intro-guide> [Accessed 5 Mar. 2015].

Lyon, J., Stuart, I., Ramsey, D. and O'Mahony, J., 2010. The effect of water level on lateral movements of fish between river and off-channel habitats and implications for management. *Marine and Freshwater Research*, 61(3), p.271.

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

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

Marchant, S. and Higgins, P., 1990. *Handbook of Australian, New Zealand & Antarctic birds*. Melbourne: Oxford University Press.

National Herbarium of New South Wales, n.d. *PlantNET Home Page*. [online] Available at: <http://plantnet.rbgsyd.nsw.gov.au/> [Accessed 2 Mar. 2016].

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

Parks Victoria, 2006. *Kings Billabong Wildlife Reserve Riverine Protection Plan*. Mildura, Victoria: Parks Victoria.

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

Pyke, G., 2002. A review of the biology of the southern bell frog Litoria raniformis (Anura: Hylidae). *Australian Zoologist*, 32(1), pp.32–48.

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

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

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

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

Scott, A., 1997. *Relationship between waterbird ecology and river flows in the Murray-Darling Basin*. CSIRO Land and Water.

Taft, O., Colwell, M., Isola, C. and Safran, R., 2002. Waterbird responses to experimental drawdown: implication for the multispecies management of wetland mosaics. *Journal of Applied Ecology*, 39, pp.987 – 1001.

Treadwell, S. and Hardwick, R., 2003. *Review of habitat associations of native fish in the Murray-Darling Basin*. Armidale, Victoria: SKM.

VEAC, 2008. *River Red Gum Investigation*. East Melbourne, Victoria: Victorian Enviornmental Assessment Council.

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

Young, W., Scott, A., Cuddy, S. and Rennie, B., 2003. *Murray Flow Assessment Tool A Technical Description*. Canberra, ACT: CSIRO Land and Water.

# Abbreviations and acronyms

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

# Appendix 1 – Fauna species list

| Common name | Scientific name | Type |
|---|---|---|
| Plains Froglet | *Crinia parinsignifera* | A |
| Barking Marsh Frog | *Limnodynastes fletcheri* | A |
| Spotted Marsh Frog (race unknown) | *Limnodynastes tasmaniensis* | A |
| Person's Tree Frog^ | *Litoria peronii* | A |
| Eastern Sign-bearing Froglet^ | *Crinia parinsignifera* | A |
| Eastern Banjo Frog^ | *Limnodynastes dumerilii* | A |
| Spiny-cheeked Honeyeater | *Acanthagenys rufogularis* | B |
| Yellow-rumped Thornbill | *Acanthiza chrysorrhoa* | B |
| Yellow Thornbill | *Acanthiza nana* | B |
| Clamorous Reed Warbler | *Acrocephalus stentoreus* | B |
| Grey Teal | *Anas gracilis* | B |
| Pacific Black Duck | *Anas superciliosa* | B |
| Darter | *Anhinga novaehollandiae* | B |
| Red Wattlebird | *Anthochaera carunculata* | B |
| Eastern Great Egret | *Ardea modesta* | B |
| White-necked Heron | *Ardea pacifica* | B |
| Dusky Woodswallow | *Artamus cyanopterus* | B |
| White-breasted Woodswallow | *Artamus leucorynchus* | B |
| White-browed Woodswallow | *Artamus superciliosus* | B |
| Little Corella | *Cacatua sanguinea* | B |
| Australian Wood Duck | *Chenonetta jubata* | B |
| Silver Gull | *Chroicocephalus novaehollandiae* | B |
| Swamp Harrier | *Circus approximans* | B |
| Brown Treecreeper (south-eastern ssp.) | *Climacteris picumnus victoriae* | B |
| Grey Shrike-thrush | *Colluricincla harmonica* | B |
| Rock Dove* | *Columba livia* | B |
| Black-faced Cuckoo-shrike | *Coracina novaehollandiae* | B |
| White-winged Chough | *Corcorax melanorhamphos* | B |
| Australian Raven | *Corvus coronoides* | B |
| Pied Butcherbird | *Cracticus nigrogularis* | B |
| Pallid Cuckoo | *Cuculus pallidus* | B |
| Black Swan | *Cygnus atratus* | B |
| Laughing Kookaburra | *Dacelo novaeguineae* | B |
| Mistletoebird | *Dicaeum hirundinaceum* | B |
| Little Egret | *Egretta garzetta nigripes* | B |
| White-faced Heron | *Egretta novaehollandiae* | B |
| Black-fronted Dotterel | *Elseyornis melanops* | B |
| Galah | *Eolophus roseicapilla* | B |
| Nankeen Kestrel | *Falco cenchroides* | B |
| Eurasian Coot | *Fulica atra* | B |
| Dusky Moorhen | *Gallinula tenebrosa* | B |

| | | |
|---|---|---|
| Black-tailed Native-hen | *Gallinula ventralis* | B |
| Peaceful Dove | *Geopelia striata* | B |
| Magpie-lark | *Grallina cyanoleuca* | B |
| Chestnut teal^ | *Anas castanea* | B |
| Eastern great egret^ | *Ardea alba* | B |
| Intermediate egret^ | *Ardrea intermidea* | B |
| Little crow^ | *Corvus bennetti* | B |
| Red-kneed dotterel^ | *Erythrogonys cinctus* | B |
| Welcome swallow^ | *Hirundo neoxena* | B |
| Blue-winged parrot^ | *Neophema chrysostoma* | B |
| White-plumed honeyeater^ | *Ptilotula penicillata* | B |
| Australasian shoveler^ | *Spatula rhynchotis* | B |
| Australian white ibis^ | *Threskiornis moluccus* | B |

| Common name | Scientific name | Type |
|---|---|---|
| Australian Magpie | *Gymnorhina tibicen* | B |
| Whistling Kite | *Haliastur sphenurus* | B |
| Little Eagle | *Hieraaetus morphnoides* | B |
| Caspian Tern | *Hydroprogne caspia* | B |
| White-plumed Honeyeater | *Lichenostomus penicillatus* | B |
| Superb Fairy-wren | *Malurus cyaneus* | B |
| Variegated Fairy-wren | *Malurus lamberti* | B |
| Noisy Miner | *Manorina melanocephala* | B |
| Little Grassbird | *Megalurus gramineus* | B |
| Hooded Robin | *Melanodryas cucullata cucullata* | B |
| Little Pied Cormorant | *Microcarbo melanoleucos* | B |
| Black Kite | *Milvus migrans* | B |
| Crested Pigeon | *Ocyphaps lophotes* | B |
| Rufous Whistler | *Pachycephala rufiventris* | B |
| Spotted Pardalote | *Pardalotus punctatus punctatus* | B |
| Striated Pardalote | *Pardalotus striatus* | B |
| Australian Pelican | *Pelecanus conspicillatus* | B |
| Welcome Swallow | *Petrochelidon neoxena* | B |
| Tree Martin | *Petrochelidon nigricans* | B |
| Red-capped Robin | *Petroica goodenovii* | B |
| Great Cormorant | *Phalacrocorax carbo* | B |
| Little Black Cormorant | *Phalacrocorax sulcirostris* | B |
| Pied Cormorant | *Phalacrocorax varius* | B |
| Common Bronzewing | *Phaps chalcoptera* | B |
| Little Friarbird | *Philemon citreogularis* | B |
| Yellow-billed Spoonbill | *Platalea flavipes* | B |
| Royal Spoonbill | *Platalea regia* | B |
| Crimson Rosella | *Platycercus elegans* | B |
| Yellow Rosella | *Platycercus elegans flaveolus* | B |
| Tawny Frogmouth | *Podargus strigoides* | B |
| Hoary-headed Grebe | *Poliocephalus poliocephalus* | B |
| Regent Parrot | *Polytelis anthopeplus monarchoides* | B |
| White-browed Babbler | *Pomatostomus superciliosus* | B |
| Purple Swamphen | *Porphyrio porphyrio* | B |
| Australian Spotted Crake | *Porzana fluminea* | B |
| Baillon's Crake | *Porzana pusilla palustris* | B |
| Red-rumped Parrot | *Psephotus haematonotus* | B |
| Grey Fantail | *Rhipidura albiscarpa* | B |
| Willie Wagtail | *Rhipidura leucophrys* | B |
| Weebill | *Smicrornis brevirostris* | B |
| Common Starling* | *Sturnus vulgaris* | B |
| Australasian Grebe | *Tachybaptus novaehollandiae* | B |
| Australian Shelduck | *Tadorna tadornoides* | B |

| Common name | Scientific name | Type |
|---|---|---|
| Australian White Ibis | *Threskiornis molucca* | B |
| Straw-necked Ibis | *Threskiornis spinicollis* | B |
| Sacred Kingfisher | *Todiramphus sanctus* | B |
| Masked Lapwing | *Vanellus miles* | B |
| Silvereye | *Zosterops lateralis* | B |
| Silver Perch | *Bidyanus bidyanus* | F |
| Goldfish* | *Carassius auratus* | F |
| Unspecked Hardyhead | *Craterocephalus stercusmuscarum fulvus* | F |
| Carp* | *Cyprinus carpio* | F |
| Eastern Gambusia* | *Gambusia holbrooki* | F |
| Western Carp Gudgeon | *Hypseleotris klunzingeri* | F |
| Golden Perch | *Macquaria ambigua* | F |
| Murray River Rainbowfish | *Melanotaenia fluviatilis* | F |
| Oriental Weatherloach* | *Misgurnus anguillicaudatus* | F |
| Bony Herring | *Nematalosa erebi* | F |
| Flathead Gudgeon | *Philypnodon grandiceps* | F |
| Dwarf Flathead Gudgeon | *Philypnodon macrostomus* | F |
| Australian Smelt | *Retropinna semoni* | F |
| Freshwater Catfish | *Tandanus tandanus* | F |
| Rakali | *Hydromys chrysogaster* | M |
| Gould's Wattle bat^ | *Chalinolobus gouldii* | M |
| Long-eared bat^ | *Nyctophilus sp* | M |
| Little Forest Bat^ | *Vespadelus vulturnus* | M |
| White-striped free-tailed bat^ | *Austronomus australis* | M |
| Southern free-tail bat^ | *Mormopterus planiceps* | M |

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

*Introduced species

^Species identified through citizen science projects.

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

# Appendix 2 – Ecological vegetation classes (EVCs)

| EVC no. | EVC name | Bioregional conservation status | Description |
|---|---|---|---|
| 103 | Riverine Chenopod Woodland | Depleted | Eucalypt woodland to 15 m tall with a diverse shrubby and grassy understorey occurring on most elevated riverine terraces. Confined to heavy clay soils on higher level terraces within or on the margins of riverine floodplains (or former floodplains), naturally subject to only extremely infrequent incidental shallow flooding from major events if at all flooded. |
| 808 | Lignum Shrubland | Least concern | Relatively open shrubland of species of divaricate growth form. The ground-layer is typically herbaceous or a turf grassland, rich in annual/ephemeral herbs and small chenopods. Characterised by the open and even distribution of relatively small Lignum shrubs. Occupies heavy soil plains along Murray River, low-lying areas on higher-level (but still potentially flood-prone) terraces. |
| 813 | Intermittent Swampy Woodland | Depleted | Eucalypt woodland to 15 m tall with a variously shrubby and rhizomatous sedgy - turf grass understorey, at best development dominated by flood stimulated species in association with flora tolerant of inundation. Flooding is unreliable but extensive when it happens. Occupies low elevation areas on river terraces (mostly at the rear of point-bar deposits or adjacent to major floodways) and lacustrine verges (where sometimes localised to narrow transitional bands). Soils often have a shallow sand layer over heavy and frequently slightly brackish soils. |
| 821 | Tall Marsh | Depleted | Wetland dominated by tall emergent graminoids (rushes, sedges, reeds), typically in thick species-poor swards. Competitive exclusion in core wetland habitat - of optimum growing conditions for species tolerant of sustained shallow inundation. Occupies wetlands usually associated with anabranch creeks. Soils are almost permanently moist. Dominant species are tolerant of relatively deep and sustained inundation, but not total immersion for any sustained period. |

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

# Appendix 3 – Flora species list

| Common name | Scientific name |
|---|---|
| Eumong | *Acacia stenophylla* |
| Lesser Joyweed | *Alternanthera denticulata* s.l. |
| Box Mistletoe | *Amyema miquelii* |
| Bridal Creeper* | *Asparagus asparagoides* |
| Asparagus* | *Asparagus officinalis* |
| Aster-weed* | *Aster subulatus* |
| Slender-fruit Saltbush | *Atriplex leptocarpa* |
| Corky Saltbush | *Atriplex lindleyi* subsp. *inflata* |
| Berry Saltbush | *Atriplex semibaccata* |
| Saltbush | *Atriplex* spp. |
| Sprawling Saltbush | *Atriplex suberecta* |
| Bearded Oat* | *Avena barbata* |
| Oat* | *Avena* spp. |
| Pacific Azolla | *Azolla filiculoides* |
| Variable Daisy | *Brachyscome ciliaris* |
| Lobe-seed Daisy | *Brachyscome dentata* |
| Hard-head Daisy | *Brachyscome lineariloba* |
| Mediterranean Turnip* | *Brassica tournefortii* |
| Great Brome* | *Bromus diandrus* |
| Red Brome* | *Bromus rubens* |
| Leek Lily | *Bulbine semibarbata* |
| Small Purslane | *Calandrinia eremaea* |
| Pale Beauty-heads | *Calocephalus sonderi* |
| Blue Burr-daisy | *Calotis cuneifolia* |
| Hairy Burr-daisy | *Calotis hispidula* |
| Plains Sedge | *Carex bichenoviana* |
| Nitre Goosefoot | *Chenopodium nitrariaceum* |
| Common Cotula | *Cotula australis* |
| Dense Crassula | *Crassula colorata* |
| Sieber Crassula | *Crassula sieberiana* s.l. |
| Couch | *Cynodon dactylon* |
| Couch* | *Cynodon dactylon* var. *dactylon* |
| Native Couch | *Cynodon dactylon* var. *pulchellus* |

| Common name | Scientific name |
|---|---|
| Flecked Flat-sedge | *Cyperus gunnii* subsp. *gunnii* |
| Spiny Flat-sedge | *Cyperus gymnocaulos* |
| Nutgrass* | *Cyperus rotundus* |
| Riverine Flax-lily | *Dianella porracea* |
| Stinkwort* | *Dittrichia graveolens* |
| Tangled Lignum | *Duma florulenta* |
| Nodding Saltbush | *Einadia nutans* |
| Ruby Saltbush | *Enchylaena tomentosa* var. *tomentosa* |
| Spider Grass | *Enteropogon acicularis* |
| Southern Cane-grass | *Eragrostis infecunda* |
| Spreading Emu-bush | *Eremophila divaricata* subsp. *divaricata* |
| Spotted Emu-bush | *Eremophila maculata* subsp. *maculata* |
| Tall Nut-heads | *Ethuliopsis cunninghamii* |
| River Red-gum | *Eucalyptus camaldulensis* |
| Black Box | *Eucalyptus largiflorens* |
| Annual Cudweed | *Euchiton sphaericus* |
| Flat Spurge | *Euphorbia drummondii* s.l. |
| Pale-fruit Ballart | *Exocarpos strictus* |
| Slender Carpet-weed | *Glinus oppositifolius* |
| Rough Raspwort | *Haloragis aspera* |
| Jersey Cudweed | *Helichrysum luteoalbum* |
| Northern Barley-grass* | *Hordeum glaucum* |
| Smooth Cat's-ear* | *Hypochaeris glabra* |
| Flatweed* | *Hypochaeris radicata* |
| Grass Cushion | *Isoetopsis graminifolia* |
| Tussock Rush | *Juncus aridicola* |
| Gold Rush | *Juncus flavidus* |
| Common Blown-grass | *Lachnagrostis filiformis* s.s. |
| Prickly Lettuce* | *Lactuca serriola* |
| Warty Peppercress | *Lepidium papillosum* |
| Native Peppercress | *Lepidium pseudohyssopifolium* |
| Peppercress | *Lepidium* spp. |
| Wimmera Rye-grass* | *Lolium rigidum* |
| Clove-strip | *Ludwigia peploides* subsp. *montevidensis* |

| Common name | Scientific name |
|---|---|
| Box Thorn | *Lycium* spp. |
| Hairy Bluebush | *Maireana pentagona* |
| Common Nardoo | *Marsilea drummondii* |
| Nardoo | *Marsilea* spp. |
| Little Medic* | *Medicago minima* |
| Small Ice-plant* | *Mesembryanthemum nodiflorum* |
| Smooth Minuria | *Minuria integerrima* |
| Grassland Wood-sorrel | *Oxalis perennans* |
| Warrego Summer-grass | *Paspalidium jubiflorum* |
| Water Couch* | *Paspalum distichum* |
| Slender Knotweed | *Persicaria decipiens* |
| Fog-fruit* | *Phyla canescens* |
| Austral Pillwort | *Pilularia novae-hollandiae* |
| Clay Plantain | *Plantago cunninghamii* |
| Floating Pondweed | *Potamogeton tricarinatus* s.l. |
| Pink Mulla-mulla | *Ptilotus nobilis subsp. nobilis* |
| False Sow-thistle* | *Reichardia tingitana* |
| Paper Sunray | *Rhodanthe corymbiflora* |
| Slender Dock | *Rumex brownii* |
| Narrow-leaf Dock | *Rumex tenax* |
| Common Wallaby-grass | *Rytidosperma caespitosum* |
| Bristly Wallaby-grass | *Rytidosperma setaceum* |
| Prickly Saltwort | *Salsola tragus* subsp. *tragus* |
| Arabian Grass* | *Schismus barbatus* |
| River Club-sedge | *Schoenoplectus tabernaemontani* |
| Short-wing Saltbush | *Sclerochlamys brachyptera* |
| Streaked Copperburr | *Sclerolaena tricuspis* |
| Slender Groundsel | *Senecio glossanthus* s.l. |
| Cotton Fireweed | *Senecio quadridentatus* |
| Variable Sida (narrow-lf form) | *Sida corrugata* var. *angustifolia* |
| Narrow-leaf Sida | *Sida trichopoda* |
| Mallee Catchfly* | *Silene apetala* var. *apetala* |
| Smooth Mustard* | *Sisymbrium erysimoides* |
| Quena | *Solanum esuriale* |

| Common name | Scientific name |
|---|---|
| Rough Sow-thistle* | *Sonchus asper* s.l. |
| Common Sow-thistle* | *Sonchus oleraceus* |
| Salt Sea-spurrey | *Spergularia brevifolia* |
| Rat-tail Couch | *Sporobolus mitchellii* |
| Star Bluebush | *Stelligera endecaspinis* |
| Desert Spinach | *Tetragonia eremaea* s.l. |
| Grey Germander | *Teucrium racemosum* s.l. |
| Cluster Clover* | *Trifolium glomeratum* |
| Woolly Clover* | *Trifolium tomentosum* var. *tomentosum* |
| Eel Grass | *Vallisneria americana* var. *americana* |
| Common Verbena | *Verbena officinalis* s.l. |
| Annual New Holland Daisy | *Vittadinia cervicularis* var. *subcervicularis* |
| Dissected New Holland Daisy | *Vittadinia dissecta* s.l. |
| Rat's-tail Fescue* | *Vulpia myuros* f. *myuros* |
| River Bluebell | *Wahlenbergia fluminalis* |
| Bluebell | *Wahlenbergia* spp. |
| Noogoora Burr species aggregate* | *Xanthium strumarium* s.l. |
| Sand Twin-leaf | *Zygophyllum ammophilum* |
| Pointed Twin-leaf | *Zygophyllum apiculatum* |

*Introduced species

Source: (DELWP, 2016)