North Central CMA Region
Loddon River System
Environmental Water Management Plan





EWMP Area: Loddon River downstream of Cairn Curran Reservoir and including Tullaroop Creek downstream of Tullaroop Reservoir, Serpentine Creek, Twelve Mile Creek and Pyramid Creek

NORTH CENTRAL
Catchment Management Authority
Connecting Rivers, Landscapes, People

Department of Environment, Land, Water & Planning

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Front cover photo: Top Left: Loddon River Reach 1 near Rumbolds Road - Source; Jacobs 2015a; Middle Left: Loddon River Reach 3a at Newbridge - Source: Louissa Rogers (NCCMA); Top Right: Floodwaters receding from Canary Island (Reach 4b and 4c) showing Loddon Fan formation - Source: Phil Slessar (NCCMA), Middle Right: Loddon River Reach 4a -Source: Phil Slessar (NCCMA), Bottom: Loddon River Reach 5 near Benjeroop - Source: Louissa Rogers (NCCMA).

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Executive Summary

The Loddon River System Environmental Water Management Plan (EWMP) sets out long-term management objectives for priority water dependent environmental values of the Loddon River System. The area that the Loddon River System EWMP covers includes the Loddon River downstream of Cairn Curran Reservoir to the Murray River, Tullaroop Creek downstream of Tullaroop Reservoir, Serpentine Creek, Twelve Mile Creek and Pyramid Creek. The EWMP is an important part of the Victorian Environmental Water Planning Framework. It provides the ten year management intentions (with potential for mid-term review), based on scientific information and stakeholder consultation, that can be used by the respective agencies; North Central Catchment Management Authority (CMA), Department of Environment, Land, Water and Planning (DELWP) and the Victorian Environmental Water Holder (VEWH); for both short and longer-term environmental water planning.

This EWMP is not a holistic management plan for the river, but is focused on environmental water management so that the Loddon River System can continue to provide environmental, social, cultural and economic values for all users. The following components are the main sections featured in the Loddon River System EWMP.

Hydrology and system operations

Prior to regulation the Loddon River would have experienced high flows in winter and spring, with regular (multiple times a year in most years) occurrences of minor to moderate flooding of the floodplain. In summer and autumn, as inflows from the catchment reduce, the unregulated Loddon River System would experience lower flows with cease-to-flow events occurring in most years. Under current conditions flow in the Loddon River System is regulated by the operation of the Cairn Curran and Tullaroop reservoirs, as well as a series of weirs (Laanecoorie Reservoir, Bridgewater Weir, Serpentine Weir, Loddon Weir and Kerang Weir) that either re-regulate flow or pool water for diversion to the floodplain. The Loddon River System also receives inflows from other river systems, including the Goulburn River (via the Waranga Western Channel) and the Murray River (via the National Channel and Kow Swamp). Due to river regulation flows in the Loddon River System are characterised by reduced frequency of minor to moderate overbank flow, reduced high and bankfull flows in winter and spring and increased flow magnitude and duration over the irrigation season (usually late spring, summer and early autumn).

Water dependent values

The Loddon River System supports populations of threatened native fish, including the nationally vulnerable Murray Cod and critically endangered Silver Perch, the State threatened Murray-Darling Rainbowfish and the regionally significant River Blackfish. The river provides important in-stream habitat for other aquatic fauna such as the near threatened Platypus. It has a relatively intact River Red Gum canopy along the river banks of the upper and mid Loddon River System, and Black Box being the dominant canopy species in the lower Loddon. Many of the native vegetation communities located along and within the Loddon River System are endangered or vulnerable.

Ecological condition and threats

According to the Sustainable River Audit, Index of Stream Condition and the Victorian Environmental Flows Monitoring and Assessment Program (VEFMAP), the Loddon River System is currently in relatively poor condition. Its native fish populations, in particular its large bodied fish, are significantly degraded with monitoring catches consistently recording very low abundances, particularly when compared to historic records, over the last six years. The Platypus population was significantly impacted by the Millennium Drought, with the community noting a marked decrease in the frequency of sightings. The riparian zone primarily comprises a mixed aged canopy species, although recruitment levels of River Red Gum is low and understorey shrubs and groundcover is relatively degraded. These key components of the river ecology require targeted management of environmental water to facilitate natural recruitment.

Management objectives

A long-term management goal has been defined for the Loddon River System:

> **Loddon River system long term management goal**
>
> Promote a widespread and diverse aquatic fauna community particularly native fish and Platypus, by providing high quality breeding and feeding habitat and where possible facilitating movement throughout the Mid-Murray Floodplain System. Rehabilitate riparian River Red Gum vegetation communities along the river and where possible connect floodplain habitats through the provision of an appropriate flow regime.

The ecological objectives and environmental flow recommendations that sit under the long-term management goal for the Loddon River System were first established for the Loddon River in 2002, and reviewed for the river downstream of the Loddon Weir in 2010. This assessment also included Twelve Mile Creek. Environmental flow assessments were undertaken in 2014 for Serpentine and Pyramid Creeks. The ecological objectives and flow recommendations for the Loddon River and including Tullaroop Creek and Twelve Mile Creek have been reviewed and refined during the development of this EWMP.

Managing risks to achieving objectives

The threats to achieving the ecological objectives that are external to environmental water are identified. Key threats include instream barriers to fish movement and grazing of riparian vegetation. Risks associated with the delivery of environmental water and management strategies have also been identified.

Environmental water delivery infrastructure

Constraints to the delivery of environmental flow recommendations (such as bankfull flows) have been identified. Infrastructure recommendations have been made and include investigating the feasibility of increasing the delivery capacity of Cairn Curran, Tullaroop and Laanecoorie reservoirs and the upgrade of in-stream structures to provide connectivity for aquatic fauna.

Demonstrating outcomes

Monitoring is required to allow the CMA to adaptively manage annual environmental watering (intervention monitoring). It is also required to enable the CMA and VEWH to demonstrate the long term outcomes of the implementation of the Loddon River System EWMP. As the State is currently reviewing the Victorian Environmental Flows Monitoring and Assessment Program (VEFMAP), the Loddon River System EWMP recommends a suite of intervention and long-term monitoring activities that will meet these monitoring requirements.

Consultation

Key stakeholders, including DELWP, VEWH and Goulburn Murray Water (GMW) have been engaged during the development of this EWMP. Three Community Advisory Groups were established for the update of the Loddon River Environmental Flow Recommendations and two Project Advisory Groups were established for the Serpentine and Pyramid creeks Environmental Flows Assessments. These community groups contributed valuable local and historical knowledge that enhanced the North Central CMAs understanding of the environmental values and hydrological nature of the Loddon River System. Additionally, the Loddon River Environmental Water Advisory Group was consulted on the Seasonal Watering Proposal (2015-16), which incorporated new and updated environmental flow recommendations.

Knowledge Gaps

The management actions in the Loddon River System EWMP are based on the best available information. A number of knowledge gaps have been identified during the development of the EWMP that relate to watering requirements of environmental values and the effectiveness of management strategies to mitigate risks.

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Acknowledgements

Acknowledgement of Country

The North Central Catchment Management Authority acknowledges Aboriginal Traditional Owners within the region, their rich culture and spiritual connection to Country. We also recognise and acknowledge the contribution and interest of Aboriginal people and organisations in land and natural resource management.

Contributions to the Loddon River EWMP

The information contained in the Loddon River System EWMP has been sourced from a variety of reports and field inspections and from individual knowledge and expertise. The North Central Catchment Management Authority acknowledges the assistance of the following people in preparing this EWMP:

- The Upstream, Midstream and Downstream Loddon River EWMP Community Advisory Groups, and the Pyramid and Serpentine creeks Project Advisory Groups (Appendix 1)
- Andrea Keleher, Suzanne Witteveen, Susan Watson and Melanie Tranter (on behalf of), Department of Environment, Land, Water and Planning (DELWP)
- Mark Toomey and Caitlin Davis, Victorian Environmental Water Holder (VEWH)
- Andrew Shields, Dylan Ferguson, Lawrence Cameron, Khane Mason, Dale Farnsworth (GMW)
- Andrew Sharpe, Peter Sandercock, Amanda Woodman (Jacobs), Paul Boon (Dodo Environmental), Justin O'Conner (Arthur Rylah Institute) Melody Serena (Australian Platypus Conservancy) (Environmental Flows Technical Panel)
- Jon Leevers (Jon Leevers Environmental Consulting) – co -author
- Louissa Rogers, Phil Slessar, Brad Drust, Michelle Maher, Emer Campbell, Anna Chatfield, Kira Woods, Peter McRostie (North Central Catchment Management Authority).

1 Introduction

The North Central Catchment Management Authority (CMA) is being funded through the Department of Environment, Land, Water and Planning (DELWP) 'Victorian Basin Plan Environmental Water Management Plan Program' to prepare an Environmental Water Management Plan (EWMP) for the Loddon River and associated waterways (the Loddon River System).

1.1 Purpose and scope of the Loddon River System Environmental Water Management Plan

The Loddon River System EWMP is a ten-year management plan that establishes the long-term water management goal based on the priority water dependent environmental values and their ecological condition. It defines the ecological objectives and recommends an environmental flow regime to achieve these objectives. The EWMP is based on both scientific information and stakeholder consultation and will be used by the North Central CMA when making annual environmental watering decisions, as well as by DELWP and the Victorian Environmental Water Holder (VEWH) for both short and longer-term environmental water planning (Department of Environment and Primary Industries [DEPI] 2014a).

The key purposes of the EWMP are to:

- identify the long-term objectives and water requirements for the Loddon River System
- provide a vehicle for community consultation, including for the long-term objectives and water requirements of the river
- inform the development of annual seasonal watering proposals and seasonal watering plans, and
- inform Long-term Watering Plans that will be developed by the State under the Chapter 8 of Basin Plan (DEPI 2014a).

The scope of this EWMP covers the regulated reaches of the Loddon River and four associated streams. Specifically this includes:

- The main channel of the Loddon River System from downstream of Cairn Curran reservoir to its junction with the Murray River, and
- Key streams including:
    - Tullaroop Creek downstream of Tullaroop reservoir (a tributary stream)
    - Serpentine Creek (a distributary stream)
    - Twelve Mile Creek (an anabranch)
    - Box and Pyramid creeks, herein called Pyramid Creek (a tributary stream)

Key waterways in the Loddon catchment that sit outside the scope of this EWMP include:

- Birch's Creek (which outfalls into the Tullaroop Creek) which will be addressed through a separate EWMP as it has its own environment water allocation under the Environmental Entitlement (Birch's Creek – Bullarook System) 2009.
- Gunbower Creek and Lagoons which will also be addressed through separate EWMP as management of environmental watering in the creek is tied in with watering of the Gunbower Forest which is a Living Murray Icon Site.
- Little Murray River is the subject of an investigation and proposed works program under the GMW Connections Project. A separate EWMP will be developed under this program.
- Wetlands in the Boort, Kerang and Central Murray Wetland complexes that receive environmental water have site specific EWMPS

All other waterways in the Loddon River System are not currently managed with environmental water and therefore are not included in this EWMP. Some of these waterways have been identified as having water dependent environmental values and will be investigated into the future (Section 12).

1.2 Background

Management of environmental water is planned and implemented through a framework of key documents. Figure 1 illustrates the strategies, scientific reports and operational documents required for environmental water management in Victoria (DEPI 2013a).

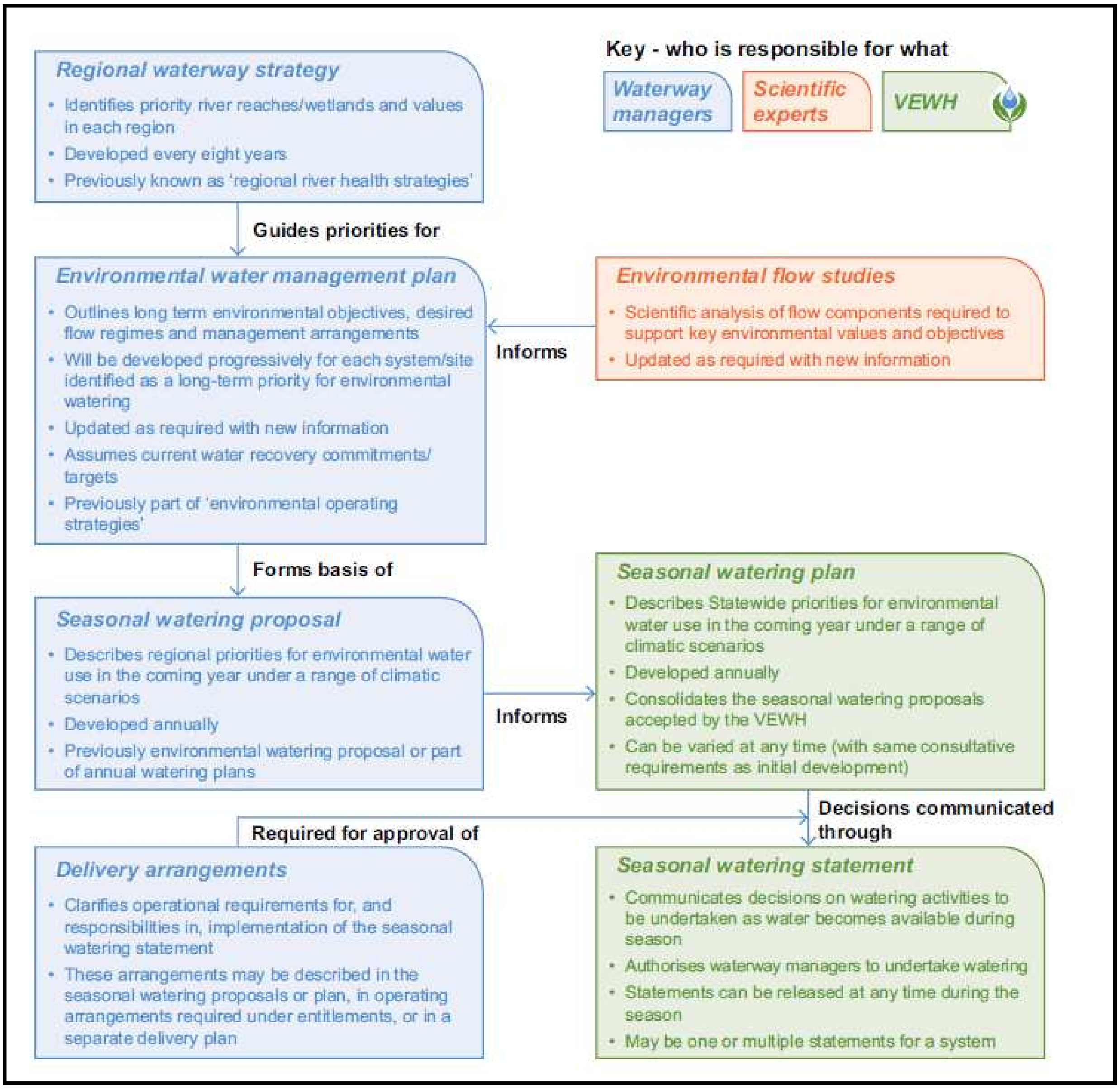

Figure 1: Planning framework for decisions about environmental management in Victoria

The North Central CMA has recently developed the 2014 - 2022 North Central Waterway Strategy (NCWS) which is an integrated strategy for managing and improving the region's waterways (rivers, streams and wetlands). The strategy sets priorities and outlines a regional works program to guide investment over the next eight years (North Central CMA 2014a). The NCWS long term resource condition targets for Loddon River System are:

Loddon River below Cairn Curran including Twelve Mile and Serpentine creeks:

- Improvement of the condition of the riparian zone of the Lower Loddon River and Serpentine Creek by 2021 with a measured increase by one in the Index of Stream Condition (ISC) streamside zone sub-index.
- Delivery of environmental flows maximised, contributing to increased hydrology and aquatic life ISC scores by 2021.
- Maintain all improvements in ISC scores through maintenance program.

Tullaroop Creek:

- Improvement in the condition of Tullaroop Creek reaches 18 and 19[1] from poor to moderate (based on ISC) by 2050.
- Improvement of one in the ISC streamside zone subindex along the Tullaroop Creek by 2025.

Pyramid Creek:

- Improvement in the condition of Pyramid/Box Creek from poor to moderate (based on ISC) by 2050.
- Improvement in the condition of the riparian zone of Pyramid/Box Creek with a measured increase of two points in the streamside zone sub-index of the ISC.
- Delivery of environmental flows maximised, contributing to increased hydrology and aquatic life ISC scores.
- Maintain all improvements in ISC scores through maintenance program.

1.3 Development process

The Loddon River System EWMP has been developed in collaboration with stakeholders including Loddon River community members, DELWP, VEWH and Goulburn Murray Water (GMW). A number of tasks were undertaken to develop the EWMP including:

- **Scoping and collating information**: a significant amount of technical work, monitoring and research has been undertaken on the Loddon River to date.
- **Updating the Loddon River Environmental Flow Assessment**: two Environmental Flows Assessments have been undertaken for the Loddon River. The first, in 2002, assessed the main river stem from Cairn Curran to the Murray River and included Tullaroop Creek. The second was undertaken in 2010 included the main river stem downstream of the Loddon Weir and incorporated Twelve Mile Creek. An Environmental Flows Technical Panel (EFTP) was convened to refine the ecological objectives and update the flow regime (including rerunning the HEC-RAS model) based on monitoring results and up-to-date scientific understandings on flow requirements of flora and fauna for the main river stem and Tullaroop and Twelve Mile creeks.
- **Undertaking environmental flows assessments for Serpentine Creek and Pyramid Creek**: full environmental flow assessments were undertaken for two creeks within the Loddon River System that were identified in the NCWS as having high environmental values to establish ecological objectives and flow regimes for the two creeks.
- The outputs of these three tasks were analysed and provided evidence for the following sections:
    - **Water dependent values:** environmental values were derived from various sources identified during data collation. Additional data identified during the EFTP review was also incorporated, specifically related to Platypus. The water dependent values (fauna, vegetation communities and flora) are presented by reach. Social values (cultural heritage, recreation and economic) are described.
    - **Ecological condition and condition trajectory without environmental water:** the condition, as reported in the Murray-Darling Basin Wide Sustainable Rivers Audit and the Victorian statewide ISC, is discussed in light of Victorian Environmental Flows Monitoring and Assessment Program (VEFMAP) findings and analysis. The condition trajectory under a "do-nothing" scenario considers the flow regime under a system regulated for consumptive needs only.
    - **Management objectives:** the long-term management goal and the ecological objectives for the Loddon River System are based on the water dependent values recorded in the system, the current condition and the condition trajectory. The objectives are also aligned with the broader environmental outcomes proposed in the Basin Plan Environmental Watering Strategy.

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[1] Reaches 18 and 19 refer to Index of Stream Condition reaches in Tullaroop Creek. These correspond with environmental flow Reach 2 in the Loddon River Environmental Flows Study and this EWMP (See Section 2.2.2).

Hydrological objectives and the flow recommendations are based on known watering requirements of the objectives and outputs of the HEC-RAS modelling.

- o **Managing risks:** the risks to achieving the ecological objectives for the Loddon River System are based on monitoring data, community concerns and best-available river health scientific knowledge as provided by the EFTP. Management actions to mitigate the risks are recommended (and where appropriate included as complementary actions).

  Risks associated with the delivery of environmental water are also documented. Management actions to mitigate these risks relate to intervention monitoring and operational decision making.

  Residual risk assumes that management actions are fully implemented.

- o **Environmental water delivery infrastructure:** current constraints in delivering the environmental flow recommendations are identified.
- o **Demonstrating outcomes:** monitoring to adaptively manage the delivery of environmental water and to demonstrate the outcomes against the ecological objectives are based on best available science monitoring method and workshop outcomes with the VEWH.
- o **Knowledge gaps and recommendations:** knowledge gaps were identified during the process of developing the ecological objectives, management actions and undertaking the risk analysis. An action list with timeframes has been developed whilst developing the EWMP, including a review of this EWMP in five years' time.

- **Consultation**: consultation activities included presenting components of the EWMP to the Loddon Environmental Water Advisory Group (LEWAG) and convening five community advisory groups, namely:
  - o The Upstream Loddon River EWMP Community Advisory Group
  - o The Midstream Loddon River EWMP Community Advisory Group
  - o The Downstream Loddon River EWMP Community Advisory Group
  - o The Serpentine and Pyramid creeks Flows Study Project Advisory Group

  Appendix 1: Loddon River EWMP Consultation lists the participants and provides a summary of the consultation outcomes.

2 Site overview

The Loddon River catchment extends from the Great Dividing Range in the south to the Murray River in the north. It covers a total area of approximately 15,000 square kilometres, which corresponds to approximately 50 per cent of the North Central CMA region and approximately 1.4 percent of the Murray-Darling Basin. The catchment is approximately 235 km long and is up to 90 km wide.

2.1 Site location

The Loddon River is Victoria's second longest river flowing for approximately 430 km north from its headwaters near Daylesford towards the Murray River (Figure 2). The Loddon River catchment lies in the centre of the North Central CMA region and is bordered by Mount Alexander in the south - east and by a series of sedimentary hills rising to above 400 m in the south-west. The north of the catchment is characterised by alluvial plains.

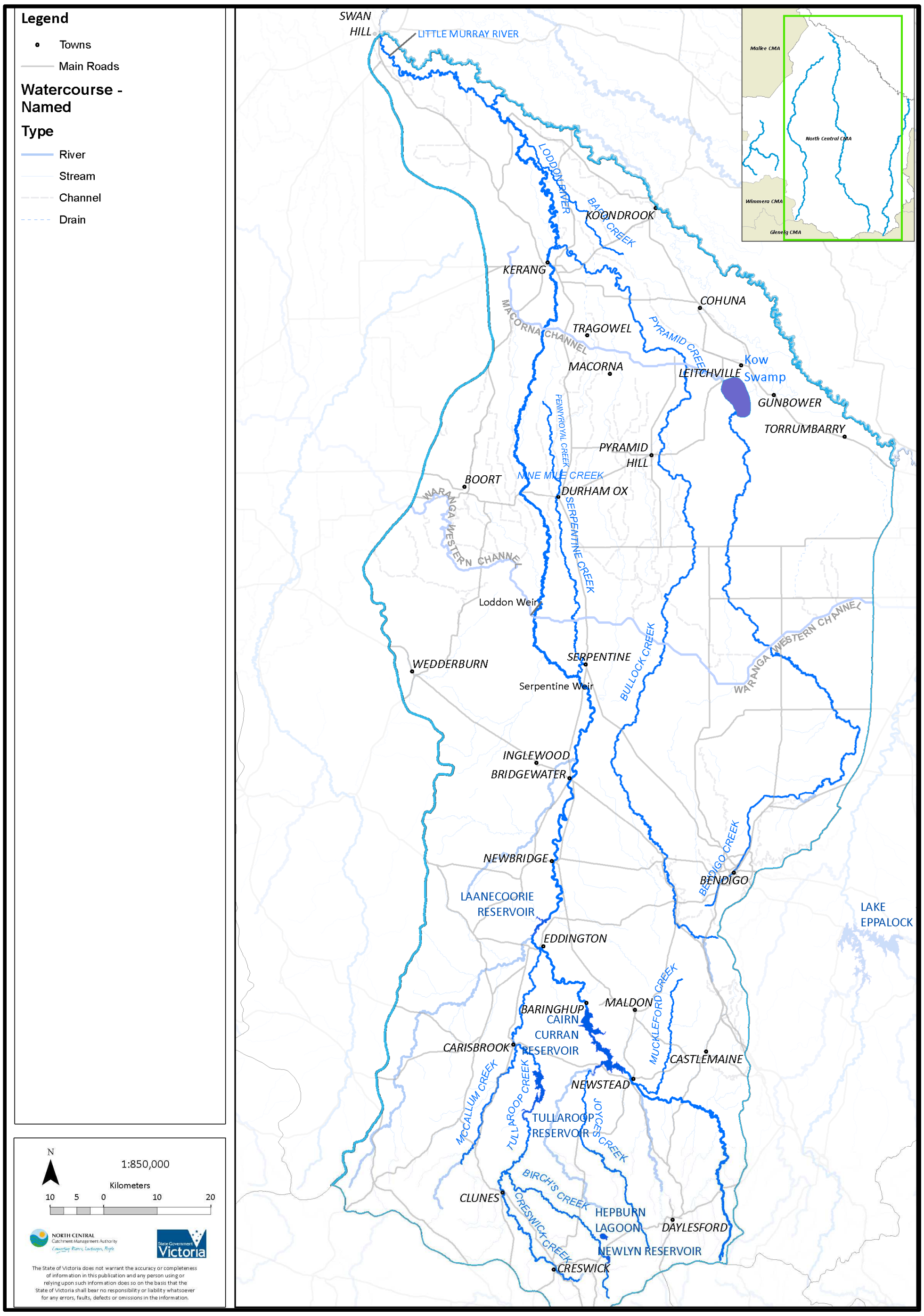

Figure 2: Location of the Loddon River System

2.2 Catchment setting

2.2.1 Climate

Annual rainfall in the Loddon River catchment ranges from up to 800 mm in the south to around 300 mm in the arid northern areas with an average across the catchment of 430 mm. Rainfall is generally higher in the winter half of the year and most of the runoff occurs in winter and early spring. The majority of surface runoff is generated in the upper catchment above Laanecoorie Reservoir (Loddon River Environmental Flows Scientific Panel [LREFSP] 2002a).

2.2.2 Hydrophysical characteristics

The Loddon River System has an unusual morphology (Jacobs 2015a). As seen in other river systems the river headwaters are located on the upland slopes and the main stem is fed by a series of tributaries, which contribute to an increase in channel size as it flows north (Jacobs 2015a; LREFSP 2002a). However at around 200 kilometres from its source the gradient significantly decreases and the river breaks into a number of anastomosing distributary channels and anabranches that carry water away from the river onto the floodplain which reduces the capacity of the main stem. At around 350 kilometres from its source, the river channel capacity again increases as anabranches re-join the main channel. On the eastern side of the Loddon Fan, the distributary streams that flow north enter the system as tributaries to Kow Swamp or Pyramid Creek (Jacobs 2015a; LREFSP 2002a) which enters the Loddon River at the Kerang weir pool. From Kerang Weir a number of anabranches, distributary and tributary streams, the primary one being Barr Creek, continue to influence capacity and flows until the river reaches the Little Murray River confluence. Figure 3 illustrates the change in profile commencing from its source in the Great Dividing Range to the Little Murray River. Due to the very low gradient Serpentine Creek and Pyramid Creek are not illustrated as they have very similar profiles to Reach 4.

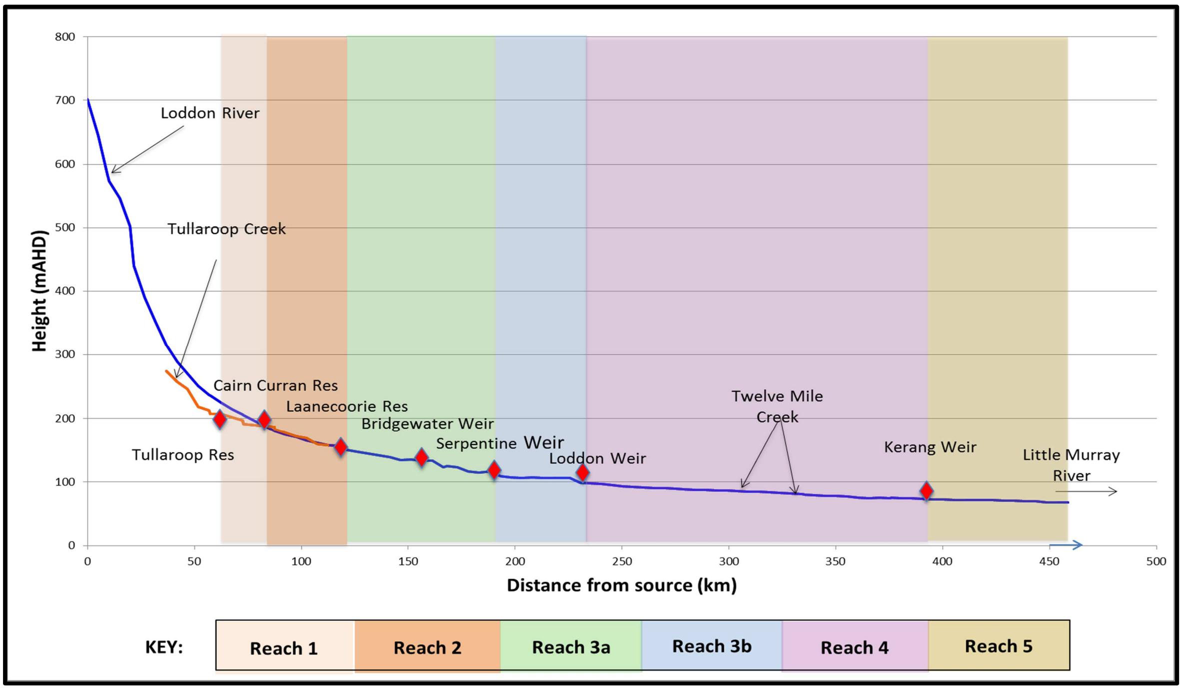

Figure 3: Profile of Loddon River

The upland and slope sections of the Loddon River System are delineated by the Cairn Curran and Tullaroop reservoirs, which are major water storages that harvest natural inflows from the upper catchment. The waterways upstream of Cairn Curran that flow into the reservoir near Newstead include the upper Loddon River and Campbells, Muckleford, Jim Crow, Joyces and Middle creeks. Birch's and Creswick creeks provide inflows to Tullaroop Reservoir on Tullaroop Creek. These upper catchment streams flow through sedimentary rises and/ or basalt country (North Central CMA 2006).

Downstream of Cairn Curran and Tullaroop reservoirs the Loddon River is divided into a number of sections by artificial instream structures, the Laanecoorie reservoir wall, Bridgewater Weir, Serpentine Weir, Loddon Weir and Kerang Weir. Between Loddon Weir and Kerang Weir, the Twelve Mile Creek forms an anabranch to the east of the Loddon Main Stem. Serpentine Creek leaves the river at Serpentine Weir and Pyramid Creek enters the river at Kerang Weir.

For the purposes of setting environmental flow recommendations the Loddon River System has been divided into environmental flow reaches (LREFSP 2002a; SKM 2010b; Jacobs 2014b; Jacobs 2014g; Jacobs 2015a) which are shown in Figure 4. For the purposes of this EWMP these have been allocated to three geographical categories (upper, mid and lower Loddon River System) and are described in detail in the following sections (Jacobs 2014c).

2.2.2.1 Upper Loddon River System

The upper Loddon River System comprises two primary streams; the Loddon River proper and Tullaroop Creek; that flow from the slopes of the Great Dividing Range through the Victorian Volcanic and Central Goldfields bioregions across sedimentary and basaltic material (Figure 4). These streams, together with the unregulated Bet Bet Creek, join at Laanecoorie Reservoir from which the river comprises a single channel flowing across an alluvial plain through the Victorian Riverina bioregion to the Loddon Weir (Figure 4). A detailed description of each reach is shown in Table 1.

Table 1: Hydrophical chracteristics of the environmental flow reaches in the upper Loddon River System

Waterway	Reach	Description
Loddon River	**1**	**Cairn Curran Reservoir to Laanecoorie Reservoir; Length: 34 km** The channel is between 10 to 20 metres wide with moderately sloping banks. The substrate comprises sand and gravel and appears that deep pools have been filled in with water depth predominantly less than two metres deep (LREFSP 2002b). Flow into this reach is predominantly influenced by releases from Cairn Curran, with minor catchment inflows from three ephemeral tributaries.
	3a	**Laanecoorie Reservoir to Serpentine Weir; Length: 69 km** The river downstream of Laanecoorie Reservoir has much lower stream gradient (LREFSP 2002a) and is a single defined channel that meanders primarily through a relatively confined (0.5 to 1 km wide) almost flat floodplain (North Central CMA 2006). It flows in wide sweeping meanders to the Bridgewater Weir, beyond which it develops a more sinuous flow pattern (North Central CMA 2006). The channel is between five and 40 m wide and contains well-developed pools of varying depths (North Central CMA 2006). Flow into this reach is predominantly influenced by releases from Laanecoorie reservoir; however unregulated flows from major tributaries, Bradford and Bullabul creeks, also contribute to inflow. At Serpentine Weir the Loddon River System starts to transition from a single entrenched stream that receives inflows from tributaries to a series of anastomosing distributary streams (Figure 4) (LREFSP 2002b). Serpentine Creek a significant distributary stream that diverts flows from Serpentine Weir to the east of the river northward across the mid Loddon River floodplain. Serpentine Creek is described in Table 2.

Waterway	Reach	Description
	3b	**Serpentine Weir to Loddon Weir; Length: 29 km** Although Reach 3b is below where the river starts to transition to a series of distributary and anastomosing streams (beginning in Reach 3a), it has been categorised as part of the upper Loddon River System because it receives inflows from tributary streams (as opposed to losing flow to distributary streams as occurs in the mid Loddon River System) which means its geomorphology is more like the upper reaches. It has high banks and high sinuosity with well-developed pools of varying depths (North Central CMA 2006). Reach 3b receives inflows from flows over the Serpentine Weir as well as unregulated inflows from its major tributary, Kingower/Hope Creek which enters from the west (North Central CMA 2006). This weir pool of the Loddon Weir receives inflows from the Waranga Western Channel which enters and crosses the river at this point.
Tullaroop Creek	**2**	**Tullaroop Reservoir to Laanecoorie Reservoir; Length: 46 km** The channel in this reach has steep banks and with an average width of five metres. There are pool, riffle and run sequences present with occasional pools greater two metres deep (LREFSP 2002b). Flows into this reach are predominantly influenced by releases from Tullaroop Reservoir and its major tributary, McCallum Creek (North Central CMA 2006).

2.2.2.2 Mid Loddon River System

Between Loddon Weir and Kerang Weir the Loddon River flows across the alluvial Loddon Plain and through the Victorian Riverina bioregion (DELWP 2015a). Natural levees have been formed and in some areas the Loddon River is perched higher than the surrounding floodplain (GHD 1994). Further downstream the Loddon is intersected by Macorna Main Channel.

The mid Loddon River System is dominated by a large number of distributary streams and anabranches flowing northwards across a broad floodplain up to 21km wide. These distributaries form further distributaries which include many prior streams and associated levees northward across the plain (LREFSP 2002a). This coupled with no significant tributaries in this section of the Loddon River further contributes to the narrowing of the channel capacity. Reach 4 is divided into four sub-reaches to account for Twelve Mile Creek an anabranch of the main stem (Figure 4).

Serpentine Creek also flows through the mid Loddon River floodplain and contributes to the distributary nature of the floodplain (Figure 4). This creek begins in the upper Loddon River System and its stream form transitions from a highly sinuous confined channel to a low gradient meandering channel and then branches into two distributary channels, the Nine Mile and Pennyroyal creeks (Jacobs 2014d). Detailed descriptions of the Reach 4 sub reaches and Serpentine Creek are shown in Table 2.

Table 2: Hydrophical chracteristics of the environmental flow reaches in the mid Loddon River System

Waterway	Reach	Description
Loddon River	**4a**	**Loddon Weir to Twelve Mile Creek regulator; Length: 76 km** The river in the reach has steep banks up to ten metres high for the first few kilometres. The channel capacity decreases and the banks become less steep and typically less than four metres high relative to each Loddon Fan distributary channel leaving the main stem (SKM 2010a). This reach comprises shallow to well-developed pools, particularly associated with accumulations of large wood (North Central CMA 2006; SKM 2010b). Sedimentation over the past 60 years has contributed to sediments of up to 2.5 metres thick on top of the natural streambed (SKM 2010a). Flows in this reach are influenced by inflows from the Loddon Weir (which can comprise water from the Loddon River or the Waranga Western Channel) and are can also impacted by diversions to distributary streams leaving the main stem to the west, namely: Kinypaniel Creek which flows north-westerly to Lake Boort and Venables Creek which flows north to Lake Leaghur.
	4c	**From the Twelve Mile Creek regulator offtake to its confluence; Length: 22 km** This reach has a meandering channel with a steady loss of channel capacity. The stream form is characterised by a lack of distinct pools, with very little relief along the bed (SKM 2010b). Flow in this reach is influenced by inflows from Reach 4a minus diversions down Twelve Mile Creek. Flows are also impacted by diversions to its major distributary Wandella Creek, which diverts flow to the west (to the Meran Lakes Complex) and flows north to Reedy Lake near Kerang, and a number of anastomosed channels that run across the floodplain, some of which connect to Twelve Mile Creek.
	4d	**From the Twelve Mile Creek confluence to the Kerang Weir; Length: 53 km** The river continues its meandering pattern in a well-defined single flow path. Some anastomosing channels re-enter the Loddon River in Reach 4d including the Bannacher Creek (also referred to as Bannagher Creek), which diverts water from the upper Serpentine Creek and receives inflows further north from the Serpentine Creek system via Pennyroyal Creek. These inflows have no substantial effect on the channel size (SKM 2010b). The Macorna Channel crosses the river upstream of the township of Kerang. At the downstream section of the reach the river passes through Kerang township before entering Kerang Weir pool where it is joined by Pyramid Creek. Washpen Creek is an effluent stream that diverts water from the Kerang Weir Pool to Reedy Lake. Sheepwash Creek is a major anabranch leaving the Loddon from the Kerang weir pool on the western side (North Central CMA 2006).
Twelve Mile Creek	**4b**	**The anabranch named Twelve Mile Creek; Length: 11 km** Twelve Mile Creek is a northerly flowing anabranch of the Loddon River that forms the eastern boundary of Canary Island. Twelve Mile Creek has a varied channel form, in some sections it is a single meandering channel and in other sections there are anastomosing channels leaving and re-entering the main channel (SKM 2010b). Twelve Mile Creek is a natural avulsion to the Loddon River and has a straighter channel with a lower bed level. As such, without the Twelve Mile Creek regulator, it would carry a higher proportion of low flows than the main stem of the Loddon River and in time would probably have become the primary flow path of the Loddon River.

Waterway	Reach	Description
Serpentine Creek	**S1**	**Serpentine Weir to Waranga Western Channel; Length: 22 km** This reach has high sinuosity with high steep banks. The Bannacher Creek leaves the western side of Serpentine Creek and flows between the Loddon River and Serpentine Creek. Inflows to Reach S1 are influenced by diversions from the Serpentine weir pool.
	S2	**Waranga Western Channel to No 2 Weir; Length 21 km** This reach is managed as a weir pool by Goulburn Murray Water (GMW).
	S3	**No 2 Weir to the outfall from the Irrigation Channel 7/10/Length: 18 km** This reach has a low gradient channel and is less confined. It has secondary channels and small anabranches (Jacobs 2014a; Jacobs 2014b; Jacobs 2014d).
	S4	**Irrigation Channel 7/10/1 outfall to Serpentine Creek Pennyroyal, Nine Mile and No. 12 channel regulators; Length 6km** This reach is managed as a weir pool by Goulburn Murray Water. From here Serpentine Creek splits into two separate floodplain streams, the Pennyroyal Creek and Nine Mile Creek. The Pennyroyal flows west and joins the Bannacher Creek, which rejoins the Loddon upstream north of the Macorna Channel siphon or passes into Tragowel Swamp (on the mid Loddon floodplain). Nine Mile Creek flows easterly and joins Calivil Creek which joins Bullock Creek and enters Pyramid Creek upstream of Hird Swamp.

2.2.2.3 Lower Loddon River System

The path of Pyramid Creek and the Loddon River downstream of Kerang Weir occupy the ancestral channel of the Goulburn River (LREFSP 2002b) and flow across the border of the Victorian Riverina and the Murray Fans Bioregions (Figure 4). This part of the Loddon River System is located on the Murray River floodplain and is part of the Mid-Murray Floodplain System.

Pyramid Creek is a single channel tributary stream of the Loddon River that flows north-westerly from Kow Swamp to the Loddon River near Kerang. Due to the inflows from Pyramid Creek and other tributaries and anabranches the channel capacity of the Loddon River downstream of Kerang Weir is significantly greater than in Reach 4 (SKM 2010b). Detailed descriptions of Reach 5 and Pyramid Creek environmental flow reaches are given in Table 3. Given the homogenous nature of Pyramid Creek a description is also provided for the creek as whole.

Table 3: Hydrophical chracteristics of the environmental flow reaches in the lower Loddon River System

Waterway	Reach	Description
Loddon River	**5**	**Kerang Weir to confluence with Little Murray River; Length: 70 km** This reach follows a highly sinuous path through an expansive alluvial plain and is characterised by a meandering channel form that has a relatively uniform morphology with sections up to 20m wide and 3m deep (LREFSP 2002b; SKM 2010b). Sedimentation in this reach has resulted in the formation of a series of mid-channel islands (SKM 2010b). Sheepwash Creek, which leaves the river from Kerang Weir re-enters the main channel approximately 20 km downstream. Barr Creek is a major tributary of Reach 5 and the river becomes wider and channel capacity increases where it enters (SKM 2010b). Barr Creek has been significantly modified through dredging and is considered one of the most saline inland waterways in northern Victoria (see Section 3.1.1 for more detail). The Loddon River flow enters the Murray River via the Little Murray River anabranch (SKM 2010b).

Waterway	Reach	Description
Pyramid Creek	**Whole creek**	**Kow Swamp to Kerang Weir; Length 68km** As mentioned in Section 1.1, for approximately nine kilometres of the upper section from the Kow Swamp outfall to its confluence with Bullock Creek, the creek is known as Box Creek. Pyramid Creek flows along the border of the Victorian Riverina and the Murray Fans bioregions (DELWP 2015a) across a flat alluvial plain (Figure 4). The creek has been significantly modified over time as a result of flood mitigation, irrigation and drainage works. In the late 1960s the creek was dredged to increase capacity and hydraulic efficiency. As a result the creek is now an artificially deep and narrow channel that lacks typical creek geomorphological components, such as run/riffle and pool structure (Jacobs 2014d).
	P1	**Kow Swamp to Hird Swamp; Length: 21 km** The upper section has a trapezoidal channel form with steep and eroding banks. Further downstream the channel erosion has significantly widened the channel and formed some narrow benches. Inflows are influenced primarily through releases from Kow Swamp which is part of the Mid-Murray Storages – it stores water diverted from Torrumbarry Weir and also harvests unregulated inflows from the south via the Bendigo Creek / Mt Hope Creek system. This reach also receives unregulated flows from tributaries Bullock and Calivil creeks.
	P2	**Hird Swamp to the Kerang weir pool; Length: 47 km** The channel form in this reach is quite uniform and vegetation varies according to local management conditions with some areas having quite dense fringing vegetation. Flow is influenced by inflows from P1 as well diversions to the irrigation channel network.

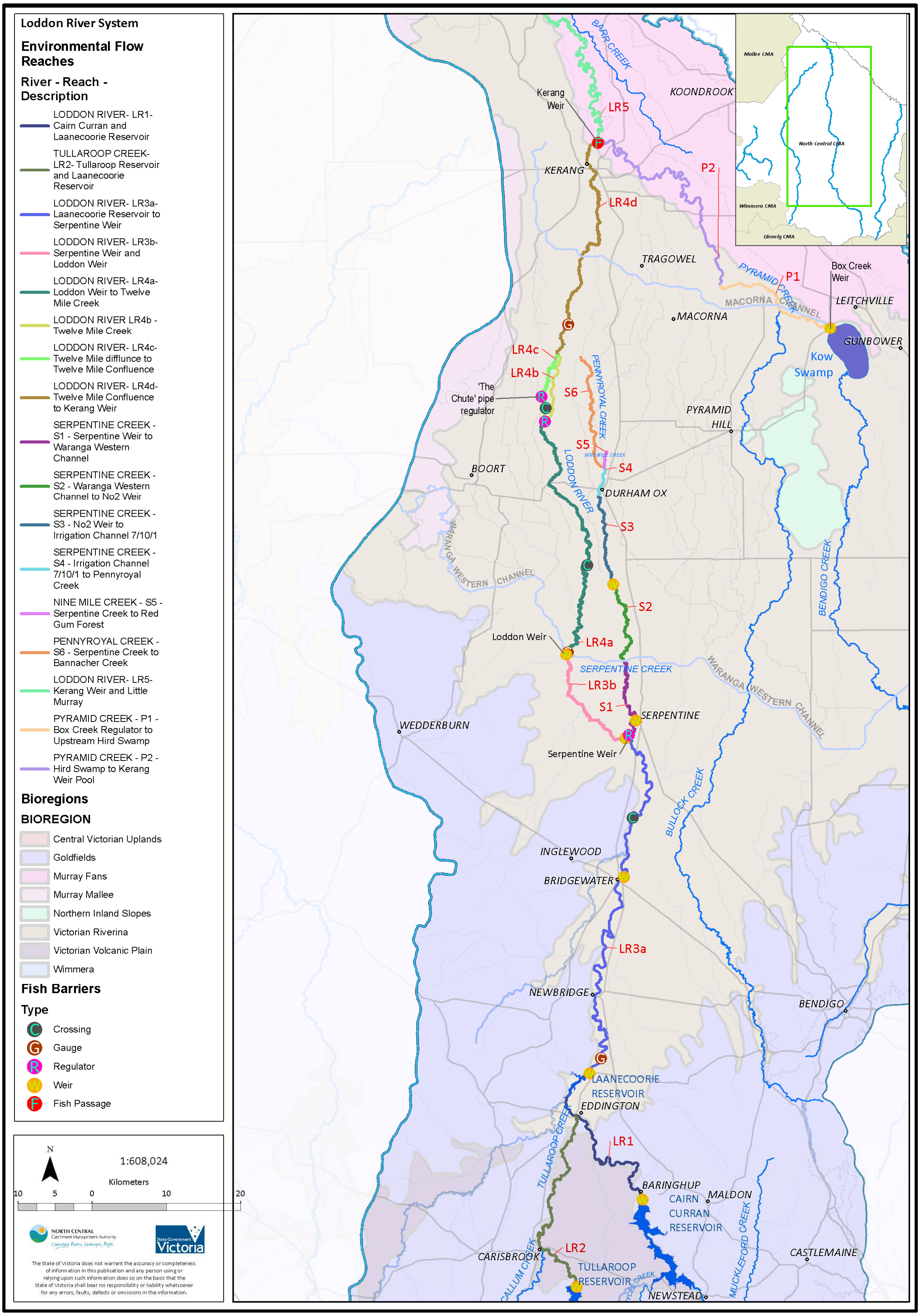

Figure 4: Loddon River System environmental flow reaches, instream structures and bioregions

2.3 Land status and management

The Loddon River System flows through rural areas as well as townships and peri-urban areas. The main townships are Carisbrook, Baringhup, Laanecoorie, Newbridge, Bridgewater, Serpentine and Kerang. The river traverses four local government municipalities: Central Goldfields, Mount Alexander, Loddon and Gannawarra Shires.

2.3.1 Land status

The Loddon River System catchment is agriculturally diverse and land use throughout the catchment consists of mixed farming, cereal growing in the upper Loddon River System and irrigated dairy, pasture and horticulture in the mid and lower system areas.

The management of riparian areas in the Loddon River System is influenced by land status. A broad overview of the land tenure for each of the key waterways covered by this EWMP is provided below:

- Across the entire Loddon River System 41% of land is licensed Crown frontage, 20% is classified as other public land and 39% is freehold land
- Twelve Mile Creek is 100% freehold land
- Serpentine Creek is 15% licensed Crown frontage, 4% other public land and 81% freehold
- Pyramid Creek is 24% licensed Crown frontage, 74% other public land and only two percent freehold

A detailed breakdown of the land tenure of riparian frontage against each of the environmental flow management units is provided in Appendix 2: Land tenure. Public land is managed by Parks Victoria and DELWP (Table 4). DELWP is also responsible for management of Crown frontage licensing (Table 4).

2.3.2 Riparian land management

The VEAC River Red Gum Forests Investigation (VEAC 2008) included recommendations for public land water frontages for the Loddon River downstream of Serpentine Weir, as well as the whole of Serpentine Creek and Pyramid Creek. The investigation recommended that public land water frontages, including those to be known as 'river reserves', be used to conserve native flora and fauna as part of an integrated system of habitat networks or corridors, to protect adjoining land from erosion, to provide for flood passage and to provide access for recreation, including hunting where appropriate. The report also recommended that stream frontages be restored with fencing, stock exclusion and revegetation as appropriate and that no new cultivation of stream frontages be permitted (VEAC 2008).

Between 2003 and 2013, the North Central CMA delivered the *Loddon Stressed Rivers Project*, and under this project extensive lengths of Loddon River frontage were fenced to protect waterways from the impact of stock access and to facilitate regrowth of riparian vegetation (North Central CMA 2015a).

Across the entire Loddon River System:

- 41% of frontage is fenced
- 4% is otherwise protected and doesn't require fencing (e.g. public reserves)
- 55% is unfenced.

Along the main stem of the Loddon River:

- 54% is fenced,
- 5% is otherwise protected
- 42% is unfenced.

Along Serpentine Creek:

- 20% is fenced
- 80% is unfenced

Along Pyramid Creek:

- 8% of Pyramid Creek is fenced,
- 7% is otherwise protected
- 85% is unfenced.

Detail of fencing by reach is shown Appendix 3: Riparian fencing.

2.3.3 Environmental water management

There are several agencies directly involved in environmental water management in Victoria, and other agencies, such as public land managers, play an important role in facilitating the delivery of environmental watering outcomes. Table 4 summarises the agencies and groups that have involvement in environmental water management in the Loddon River.

Table 4: Roles and responsibilities for environmental water and riparian land management in the Loddon River System

Agency/group	Responsibilities/involvement
Department of Environment, Land, Water and Planning (DELWP)	• Manage the water allocation and entitlements framework. • Develop state policy on water resource management and waterway management approved by the Minister for Environment, Climate Change and Water. • Develop state policy for the management of environmental water in regulated and unregulated systems. • Act on behalf of the Minister for Environment, Climate Change and Water to maintain oversight of the VEWH and waterway managers (in their role as environmental water managers). • Responsible for management of public land along waterways including licensing of Crown water frontages.
Victorian Environmental Water Holder (VEWH)	• Holds the environmental water entitlements that make up the Victorian Environmental Water Holdings and are the basis for Victoria's environmental watering program. • Make decisions about the most effective use of the Water Holdings, including use, trade and carryover. • Authorise waterway managers to implement watering decisions. • Liaise with other water holders and storage managers to ensure coordinated use of all sources of environmental water and maximise environmental outcomes from the delivery of water. • Publicly communicate environmental watering decisions and outcomes. • Commission targeted projects to demonstrate ecological outcomes of environmental watering at key sites and to improve environmental water management. • Report on management of the Water Holdings.
Commonwealth Environmental Water Holder (CEWH)	• Make decisions about the use of Commonwealth water holdings, including providing water to the VEWH for use in Victoria. • Liaise with the VEWH to ensure coordinated use of environmental water in Victoria. • Report on management of Commonwealth water holdings.
Murray-Darling Basin Authority (MDBA)	• Implementation of the Murray-Darling Basin Plan - the Basin Plan sets legal limits on the amount of surface water and groundwater that can be taken from the Basin from 1 July 2019 onwards. • Integration of Basin wide water resource management • Manager of The Living Murray water entitlements
North Central CMA *Waterway Manager*	• Identify regional priorities for environmental water management in regional waterway strategies. • In consultation with the community assess water regime requirements of priority rivers and wetlands and identify environmental watering needs to meet agreed objectives. • Identify opportunities for, and implement, environmental works to use environmental water more efficiently. • Propose annual environmental watering actions to the VEWH and implement the VEWH environmental watering decisions. • Provide critical input to and liaise with water corporation regarding management of other types of environmental water and consumptive water where feasible (passing flows management, above cap water, inter-valley-transfer water). • Report on environmental water management activities undertaken.
Goulburn Murray Water (GMW) *Storage Manager and Resource Manager*	• Work with the VEWH and waterway managers in planning for the delivery of environmental water to maximise environmental outcomes. • Operate water supply infrastructure such as dams and irrigation distribution systems to deliver environmental water. • Ensure the provision of passing flows and compliance with management of diversion limits in unregulated and groundwater systems.
Parks Victoria *Land Manager*	• Implement the relevant components of EWMPs. • Operate, maintain and replace, as agreed, the infrastructure required for delivery of

Agency/group	Responsibilities/involvement
	environmental water, where the infrastructure is not part of the GMW irrigation delivery system and is located on Parks Victoria managed land. • Where agreed, participate in the periodic review of relevant EWMPs. • Manage and report on other relevant catchment management and risk management actions required due to the implementation of environmental water. • Parks Victoria is the land manager of over 3,000 ha of public reserves on the lower Loddon and Pyramid Creek including Wildlife Reserves and Nature Conservation Reserves. Parks Victoria is land manager for Johnson Swamp, Hird Swamp and the Kerang Regional Park (Parks Victoria 2015a; VEAC 2008).
Input and advice into Loddon River System environmental watering	
Traditional Owners/ Community Groups	• Aboriginal people traditionally had a close affinity with waterways as a food source and for cultural practices. The delivery of environmental water is likely to provide benefits that support the reinvigoration of such traditional social and cultural practices. • In 2013 the State of Victoria and the Dja Dja Wurrung People signed a *Recognition and Settlement Agreement* giving recognition to traditional owner rights and an increased say in the management of Crown land in the agreement area. • Barapa Barapa and Wamba Wamba (with Wadi Wadi) have a Register Aboriginal Party application with the Victorian Government (as at June 2015). • In 2015/16 the North Central CMA will undertake a project to develop an engagement framework for annual environmental watering management
Loddon River Environmental Water Advisory Group (LEWAG)	• The Loddon River Environmental Water Advisory Group consists of key stakeholders and community representatives who provide advice to the North Central CMA on the best use of environmental water for the Loddon River.
Information from Dja Dja Wurrung 2013; DEPI 2013a; VEWH 2014.	

Other stakeholders with an interest in environmental watering include environmental groups, Landcare groups, recreational users, local government, other water entitlement holders, landholders and local communities. It is important that the interests and values of these groups are incorporated in planning for, and management of, environmental water (VEWH 2014).

2.4 Water sources

The total volume of water available to the Loddon River includes unregulated flows, environmental entitlements, passing flows and consumptive water. Each of these sources of water has different conditions and levels of certainty attached to them.

2.4.1 Unregulated flows

Unregulated flows usually occur during wet periods and after heavy rainfall. This is water that is above the limits of storage and consumption and over time makes up the largest volume of water available to the environment. The North Central CMA makes recommendations to the VEWH and GMW regarding the delivery of unregulated flows within the system (e.g. water can be diverted into wetlands on the floodplain).

2.4.2 Water entitlements

Bulk entitlements and environmental entitlements are legal rights to water which are issued with a range of conditions and obligations for taking and using water. The Water Holdings that are available for use in the Loddon River are in provided in Table 5. The VEWH holds three bulk and environmental entitlements that apply directly to the Loddon system:

- Bulk Entitlement (Loddon River – Environmental Reserve) Order 2005
- Goulburn River Environmental Entitlement 2010
- Environmental Entitlement (Goulburn System – NVIRP Stage 1) 2012

Additionally the Commonwealth Environmental Water Holder (CEWH) holds water shares in the Loddon River System. The VEWH works with the Commonwealth Environmental Water Office to make water Commonwealth Environmental Water Holdings available in the Loddon system

The allocation of water in these accounts is dependent on inflows and seasonal determinations and therefore the volumes allocated may be less than 100% of the entitlement.

A large portion of the VEWH's Water Holdings available for use in the Loddon River are derived from Goulburn system and are delivered via the Waranga Western Channel. These water holdings are only available to the Loddon River downstream of Loddon Weir during the irrigation season from 15 August to 15 May while Waranga Western Channel is in use and when there is spare channel capacity. On some occasions, when the Loddon supplement to the Goulburn is available, water allocated in the Goulburn may be sourced from the Loddon system. Outside of these times the Loddon River is reliant on releases of water from allocations in upstream reservoirs in the Loddon system or via passing flows.

Table 5: Summary of water sources available for the Loddon River System

Water Entitlement	Volume	Responsible Agency
Loddon System Water Holdings		
Bulk Entitlement (Loddon River Environmental Reserve) Order 2005	3,480 ML high reliability entitlement	VEWH
	2,024 ML low reliability entitlement	VEWH
	828 ML[2]	VEWH
	Passing flows	GMW
Commonwealth Environmental Water Holdings	3,356 ML HRWS[3]	CEWH
	527 ML LRWS	CEWH
Goulburn System Water Holdings		
Bulk Entitlement (Loddon River Environmental Reserve) Order 2005	7,940 ML high reliability entitlement	VEWH
Goulburn River Environmental Entitlement 2010	1,434 ML high reliability entitlement	VEWH
Environmental Entitlement (Goulburn System – NVIRP Stage 1) 2012	1,386 ML	VEWH

2.4.3 Environmental water available in other systems for delivery in the Loddon River and Pyramid Creek

The VEWH has the ability to trade water from other systems to Water Holdings accounts in the Goulburn or the Loddon to increase water available for use in the Loddon River. The VEWH's Bulk Entitlement (River Murray - Flora and Fauna) has been used in the past for this purpose, but water could be traded from any VEWH (or CEWH) entitlements held in the Murray system. While water is not traded to Pyramid Creek, it is possible to access water from accounts in the Murray system and deliver that water to Pyramid Creek.

2.4.4 Environmental water provided by rules and obligations under entitlements

Passing flows are volumes of water that must flow at a specific location of a river. Passing flow obligations are specified in bulk and environmental entitlements and, when that water is attributed to a VEWH entitlement, it is not available for diversion by consumptive users. In the Loddon River System a significant volume of water is set aside for the environment as passing flows for the river upstream of Kerang Weir. The Loddon River Bulk Entitlement contains rules to specify the volumes of passing flows at five locations, which vary across the reaches month to month (Table 6). The obligations also vary depending on the total volume held in storage for every reach. Further for all reaches, except Reach 4, obligations also depend on recorded inflows, so the passing flows in the upper reaches may vary from zero to 61 ML per day. North Central CMA also has authority to vary the passing flow volumes and at times may hold back water in storage for later use with agreement from the storage manager.

The storage manager may need to release water from Cairn Curran Reservoir, Tullaroop Reservoir or Laanecoorie Reservoir to meet passing flow demands throughout downstream reaches. At other times the passing flow demands may be met naturally by catchment run-off following rainfall.

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[2] Freshening flows available to manage water quality from Tullaroop and Cairn Curran reservoirs. Volumes are subject to natural inflows.

[3] Water shares are classed by their reliability and there are two types in Victoria. High-reliability water shares (HRWS), which is a legally recognised, secure entitlement to a defined share of water. Low reliability water shares (LRWS) which are water shares with a relatively low reliability of supply. Allocations are made to high-reliability water shares before low-reliability shares.

Table 6: Passing flow requirements in Bulk Entitlement (Loddon River - Environmental Reserve) 2005[4]

Month	Reach 1	Reach 2	Reach 3a	Reach 3b	Reach 4 (a,c,d)
	ML/day	ML/day	ML/day	ML/day	ML/day
Combined storage in Cairn Curran and Tullaroop >60,000 ML					
January	20	10	15	19	14
February	20	10	15	19	14
March	20	10	15	19	14
April	20	10	15	19	14
May	35	10	15	61	77
June	35	10	15	61	77
July	35	10	15	61	77
August	35	10	52	61	77
September	35	10	52	61	77
October	35	10	52	61	77
November	20	10	15	19	14
December	20	10	15	19	14
Max annual total (ML)	**10,040**	**3,650**	**8,879**	**14,644**	**16,688**
Combined storage in Cairn Curran and Tullaroop <60,000 ML					
Any time of year	20	10	15	19	14
Max annual total (ML)	**7,300**	**3,650**	**5,475**	**6,935**	**5,110**

2.4.5 Other water sources

Inter Valley Transfer – Loddon Inter Valley Trade Account

The Loddon Inter Valley Transfer (IVT) is an account which tracks water trading activity between the Loddon system and downstream water systems. Water from the Loddon River can be traded to any of the Goulburn irrigation areas (i.e. Shepparton, Central Goulburn etc), the Murray system, even South Australia and New South Wales; however any water that is traded out is owed to the Goulburn system. Water from the account is delivered from the Loddon storages to the Goulburn system via the Loddon River to the Waranga Western Channel. Water is generally supplied to the Waranga Western Channel during the peak irrigation demand periods. IVT water can be delivered to align with environmental flow recommendations.

[4] These volumes are not cumulative and apply at a reach by reach basis only.

2.5 Related agreements, policy, plans and activities

There are a number of policies, strategies, plans and activities that are specifically relevant to the environmental water management of the Loddon River. Relevant state, national and international legislation, policy and agreements include:

- State legislation (such as the *Water Act 1989*, *Catchment and Land Protection (CaLP) Act 1994*, *Flora and Fauna Guarantee (FFG) Act 1988, Aboriginal Heritage Act 2006, Traditional Owner Settlement Act 2010, Conservation, Forests and Lands Act 1987* and *Crown Land (Reserves) Act 1978*)
- National legislation, regulations and (such as the *Water Act 2007* and *Water Amendment Act 2008* (Cth), *Water Regulations 2008*, *Water Act 2007- Basin Plan 2012,* the *Environment Protection and Biodiversity Conservation (EPBC) Act 1999* and the *Native Title Act 1993*)
- International agreements (such as the Convention on Conservation of Migratory Species of Wild Animals (Bonn or CMS), Japan-Australia Migratory Bird Agreement (JAMBA), China-Australia Migratory Bird Agreement (CAMBA), Republic of Korea- Australia Migratory Bird Agreement) (ROKAMBA).

Strategies, programs and projects relevant to the Loddon River EWMP include:

- Victorian Waterway Management Strategy 2013 (VWMS). This strategy outlines the direction for the Victorian Government's investment over an eight year period. The overarching management objective is to maintain or improve the environmental condition of waterways to support environmental, social, cultural and economic values (DEPI 2013a).
- 2014-2022 - North Central Waterway Strategy. This regional strategy is an action out of the VWMS and provides the framework for managing rivers and wetlands in the North Central region over the next eight years. It delivers key elements of the VWMS including developing work programs to maintain or improve the environmental condition of waterways in the region. Actions in the North Central Waterway Strategy that are relevant to the lower Loddon system include continued delivery of environmental water to waterways and wetlands, development of environmental watering plans and delivery of complementary works such fencing, revegetation, pest plant and animal control, improvement to instream habitat and restoration of fish passage (North Central CMA 2014a).
- Victorian Environmental Flows Monitoring and Assessment Program (VEFMAP) – the Loddon River is a part of this state-wide program. The project commenced in 2006 and has funded yearly fish surveys, water quality monitoring, vegetation and physical habitat mapping for the Loddon River. The future of this program is currently uncertain, however yearly fish and vegetation surveys will continue until 2016.

3 Hydrology and system operations

3.1 River hydrology

Prior to regulation, flow in the Loddon River would have been seasonally variable, with high flows and regular flooding in winter and spring and low flows to no flow in summer and autumn (LREFSP 2002a). Early descriptions of the Loddon River System refer to multiple instances of minor to moderate flooding each year in winter and/or spring and the river and creek beds drying to a “chain of ponds” (with pools being deep, large and extensive) by late summer in most years (Haw & Munro 2010).

The Loddon River System has a long history of modification since European settlement, beginning as early as 1850 with the excavation of the cutting to connect the Loddon River with the Kinypanial Creek at much lower flows to divert water for storage in Lake Boort, Little Lake Boort and Lake Lyndger (Haw & Munro 2010). A weir at Bridgewater was first constructed in 1873 to power a flour mill and the current Bridgewater Weir was constructed in 1885 (North Central CMA 2006). Regulation of Loddon River flows began in 1889 with construction of the first Laanecoorie Reservoir. Irrigated agriculture began on a large scale with construction of the Torrumbarry Weir in 1919, Loddon Weir in 1927 and Laanecoorie Reservoir was rebuilt in 1935. Further storages including the Cairn Curran (1956) and the Tullaroop (1959) reservoirs were constructed to cater for the needs of irrigated agriculture and now the regulated Loddon River System is operated through a complex system of interconnected waterways, wetlands, channels and weirs.

River regulation has reversed the seasonal flow pattern of the upper Loddon River with water being released to meet irrigation demands increasing the magnitude of summer flows, and harvesting of inflows in winter and spring reducing the magnitude of flows and the frequency of minor to moderate flooding (LREFSP 2002b; SKM 2010b). Figure 5 shows the average flow volume over a year under modelled “natural” and “regulated without environmental water” conditions for the upper Loddon River System indicating higher flows in summer and reduced flows in winter and spring.

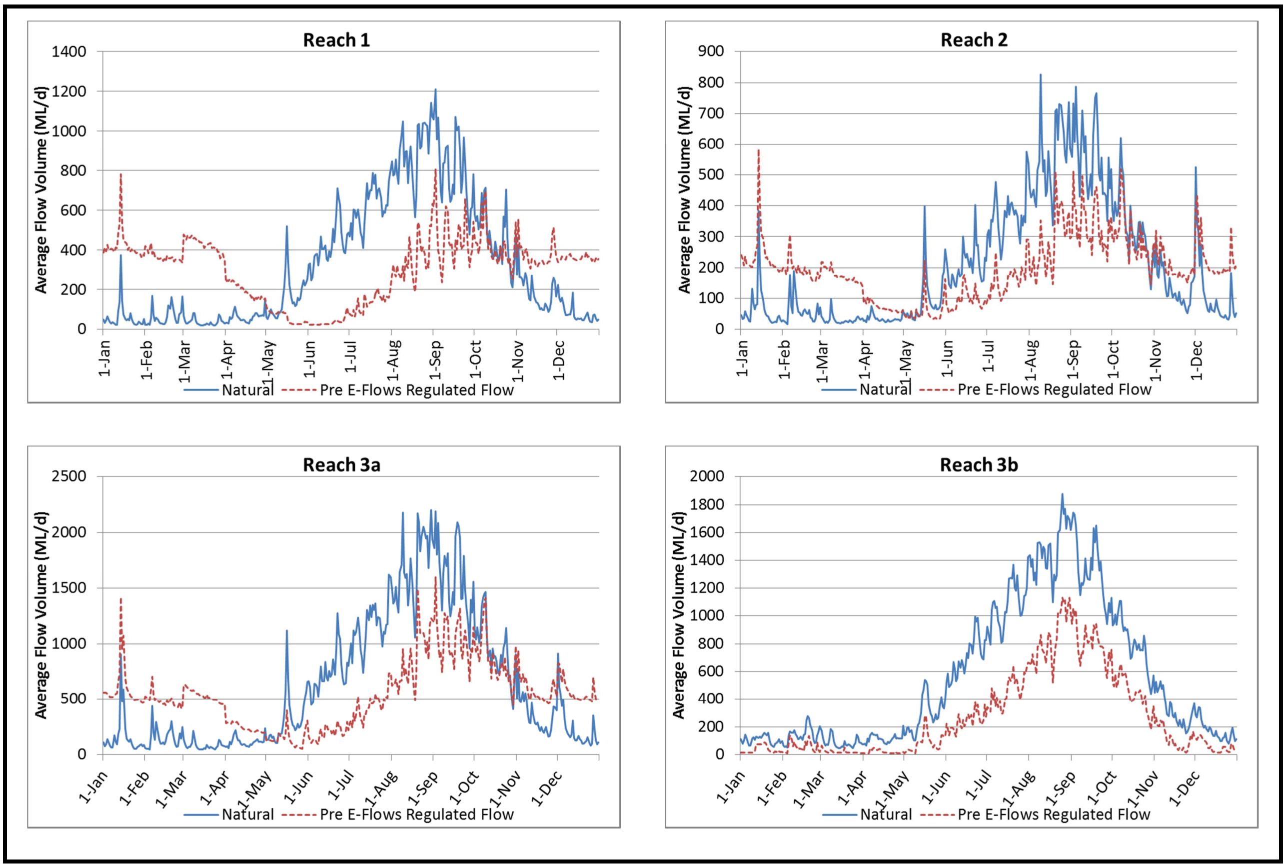

Figure 5: Pre and post regulation hydrographs of the upper Loddon River System (Source Jacobs 2015b)

Due to the distributary nature of the mid Loddon River and that the mid and lower Loddon River have been regulated for over 100 years, it is not feasible to model “natural” hydrographs for these reaches (Jacobs 2015b).

The extensive distributary nature of the floodplain to the east in particular causes sheet flooding to occur across the Loddon Plain during high flows (LREFSP 2002b). The distributary streams and anabranches would have engaged at various flows and carried water to multiple wetland complexes on the floodplain (i.e. the Boort District wetlands and Meran Complex to the west and the Tragowel Plains wetlands to the east). These wetlands largely comprise River Red Gum vegetation communities indicating moderate flooding of the floodplain occurred intermittently (every few years).

The excavation of channels, construction of levees, roads, weirs and other obstructions has significantly altered the flow patterns of the mid and lower Loddon River System. Many of the original flow paths have been significantly modified through excavations to connect waterways at lower flows (e.g. Blackfellows Cutting that connects the Loddon River to Kinypanial Creek at lower flows), dredging to move consumptive water around the landscape more efficiently (e.g. Pyramid Creek), and constructions of barriers to change the direction of flow (e.g. the Twelve Mile Regulator and the Chute). Hydrology of the wetlands has also been significantly altered with wetlands modified to hold water more permanently or drained and used for agriculture (Haw & Munro 2010). However, operation of the river main stem downstream of Loddon Weir mimicked natural seasonal flow patterns seen in the upper Loddon River, albeit with reduced flow volumes overall (Figure 6).

From the early 2000s to 2010, Victoria experienced a severe and extended drought, the Millennium Drought, during which time the Loddon River System became extremely flow stressed. Cairn Curran Reservoir remained below 40,000 ML from 2002 and dropping to below 10,000ML in 2008 for the remainder of the drought (GMW 2015a). During the peak of the drought Tullaroop Reservoir held less than 5,000 ML (GMW 2015a). Storages in the Goulburn catchment were also significantly impacted (GMW 2015a). The storage volumes impacted on allocations during this period, and the river was operated under a Ministerial Qualification of Rights for a number of years (GMW 2010).

Figure 6 shows the impact that the drought had on flow in reaches 4 and 5 when flow magnitude was significantly reduced and the river ultimately dried (SKM 2010b). Serpentine Creek reaches S1 and S3 also dried during the drought. The weir pools (reaches S2 and S3) continued to hold water throughout the drought, although levels in winter dropped lower than previously experienced (Maxted, L 2015, personal communication, [local community member], March).

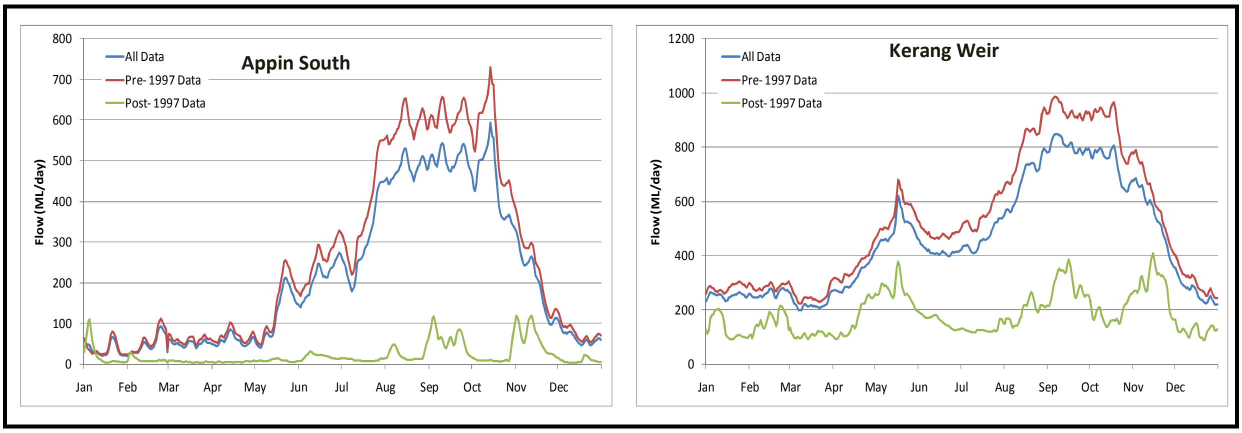

Figure 6: Average daily flow for Reach 4 and Reach 5 in the Loddon River System showing pre drought and post drought (Source SKM 2010c).

In 2010-11 widespread heavy rains across northern Victoria resulted in several instances of overbank flow occurring (Figure 7) in the Loddon River System, filling the storages and effectively “restarting” the river commencing its recovery from the drought (Slessar, P 2015, personal communication, [North Central CMA Loddon River Environmental Flows Officer], March). Further, impounded reaches of the river were connected with floodwaters drowning out most structures, possibly facilitating the movement of fish and other aquatic species throughout the river (Jacobs 2014f).

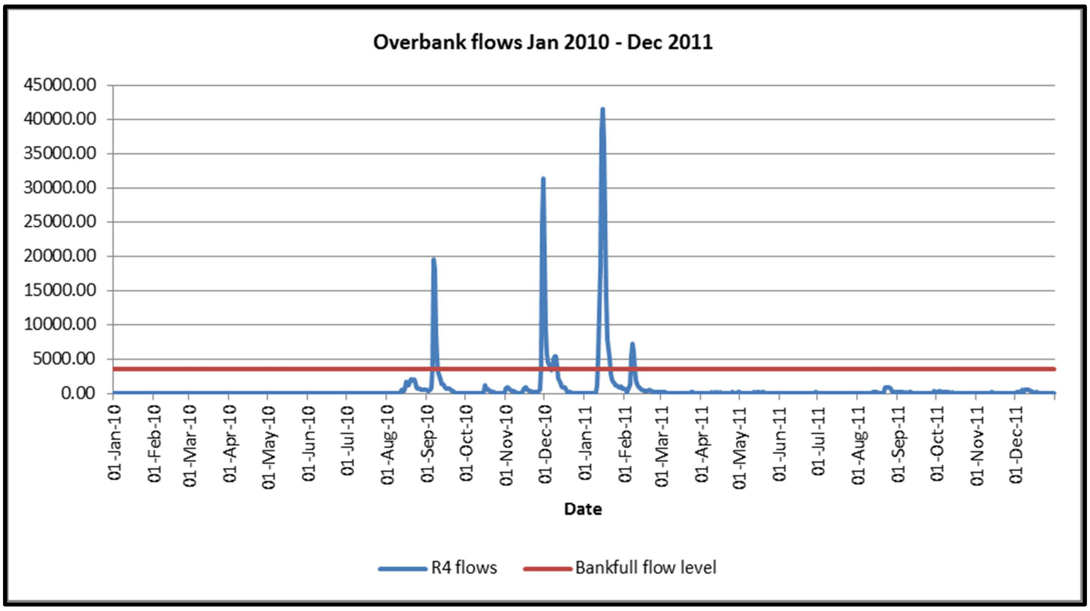

Figure 7: Overbank flow in 2010 and 2011 in Reach 4 (Source: DELWP 2015b)

3.1.1 Groundwater - surface water interaction

There is a complex interaction between surface water and groundwater in the Loddon River System due to the varied nature of the underlying sediments, and the impact of land management (land clearing and irrigation) on water table levels (Jacobs 2015a).

Groundwater in the catchment upstream of Cairn Curran and Tullaroop Reservoirs is extracted for stock and domestic, irrigation and commercial purposes which can impact base flow to the Loddon River System. Upper catchment streams that feed into Tullaroop Reservoir and the Bet Bet Creek catchment lie within the Upper Loddon Water Supply Protection Area for which a Groundwater Management Plan was developed in 2012.

Tullaroop Creek and the Loddon River to the west of Cairn Curran and downstream to Loddon Weir lie within the Mid Loddon Groundwater Management Area which had management rules developed in early 2009. These plans take into consideration the impact of groundwater on base flow on waterways when setting restrictions on groundwater extractions and assessing groundwater license applications (GMW 2015b).

The impacts of land clearing and irrigation on groundwater discharge has led to high water tables across the central and lower Loddon plains, and in the 1990s groundwater was recorded within two metres of the surface with salinity levels as high as 90,000 mg/L (GHD 1994). Groundwater studies for Serpentine Creek show that prior to the mid 1990s groundwater depths were typically within five metres of land surface with seasonal fluctuations. There was a steady decline in groundwater level from the 1990s to 2010 after which there was a sharp increase in groundwater elevations due to extensive flooding across the Loddon River catchment.

Research prior to the drought indicated Loddon River loses water to groundwater to mid-way through Reach 4a, gains water from groundwater downstream of Twelve Mile Creek and between these points is a transition zone that can fluctuate seasonally and over longer wet and dry cycles (GHD 1994).

Research undertaken during the drought found that the:

- Reaches upstream of Bridgewater, and a 45 km section of the Loddon River from north of Serpentine to Yando, gain groundwater;
- the Loddon River between Yando Road and Appin South is hydraulically neutral (i.e. neither gaining nor losing); and
- the Loddon River from Appin South to the Murray River, and the section between Bridgewater and north of Serpentine lose water to groundwater

The study also shows that falling groundwater levels affect water levels in the Loddon River (Jacobs 2015a) (Figure 8).

During extended wet periods the upper Loddon River and Serpentine Creek are likely to receive input to its baseflow from groundwater (Jacobs 2014b; Jacobs 2015a). During extended dry periods as groundwater levels fall the potential for discharge into the creek is reduced and there may be some water loss to the groundwater table (Jacobs 2014d).

The dredging of Pyramid Creek in the late 1960s resulted in the creek bed intersecting the shallow groundwater aquifer (MDBA 2011). Anecdotally the creek would often be crystal clear when groundwater flows were high (Hall, B 2015, personal communication, [local landholder] 19 March). The Pyramid Creek Salt Interception Scheme comprises a network of 87 bores along the upper reaches of Box Creek that are designed to lower groundwater to prevent discharge to the creek and prevent 22,000 tonnes of salt per year from entering the creek. This is currently lowering groundwater levels and controlling groundwater and surface water interaction in Pyramid/Box Creek though groundwater levels did rise following the 2010 / 2011 extended wet period (Jacobs 2014e).

Barr Creek was also dredged in the 1960s to facilitate drainage from the floodplain. This creek was recognised as the single largest point source of salt to the Murray River (SKM 2009), however two actions have decreased this risk, namely diversion of water directly from Barr Creek to Lake Tutchewop, and implementation of the Barr Creek Catchment Strategy, which has reduced recharge to the groundwater table and subsequent discharge to the bed of Barr Creek (SKM 2009).

Other streams, lakes and wetlands in the region have similar complex interactions between surface and groundwater (GHD 1994).

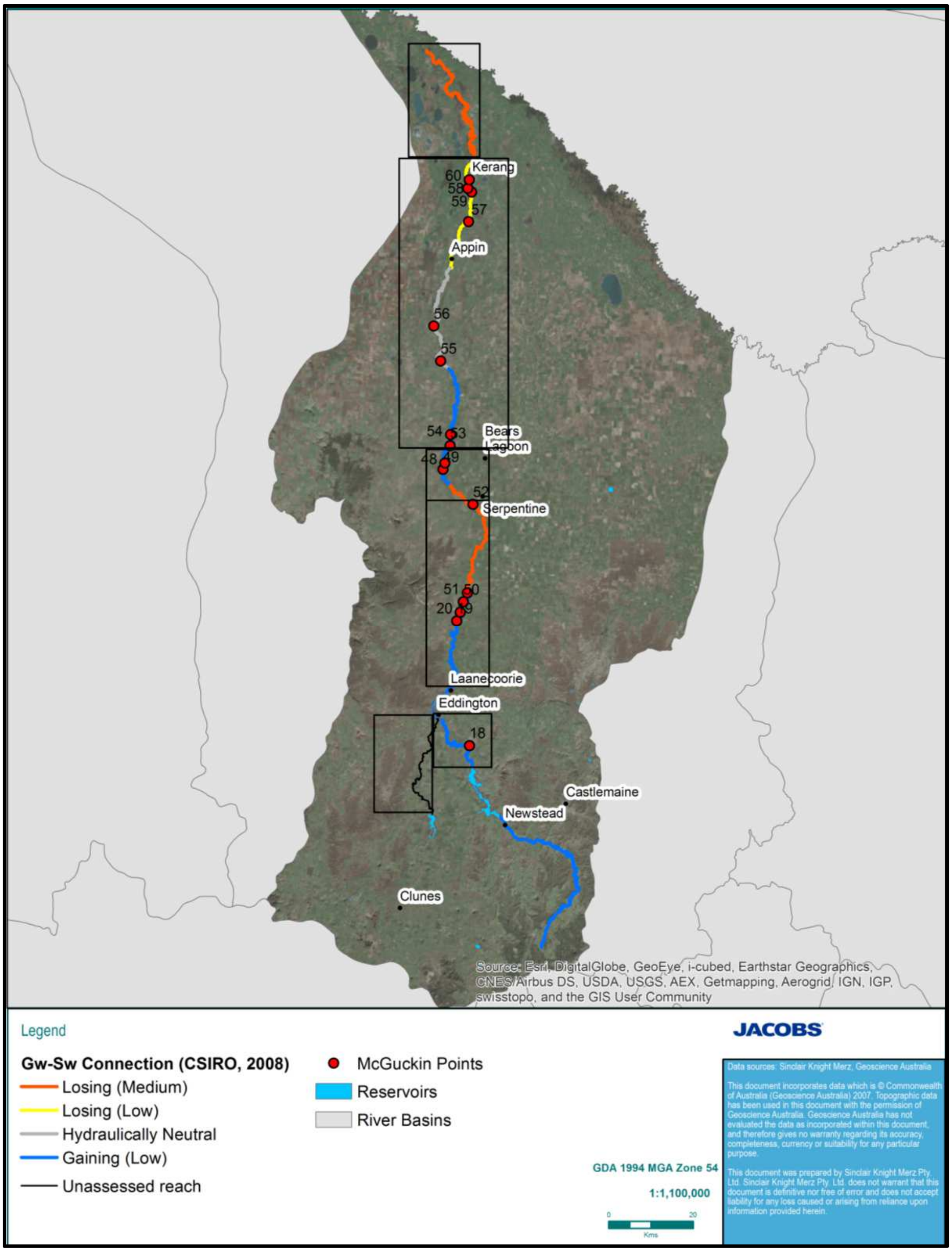

Figure 8: Groundwater - surface water interaction of the Loddon River (Source: Jacobs 2015).

3.1.2 Water quality

Other than the salinity risks posed by saline groundwater intrusion other water quality issues in the Loddon River are described in the sections below.

3.1.2.1 Turbidity

Tullaroop Creek can experience elevated turbidity, with the source most likely being degraded tributaries downstream of the Reservoir. Laanecoorie Reservoir also has high turbidity, which is worsening through time (LFRESP 2002b). The mid and lower Loddon River System is characterised by high turbidity levels (Jacobs 2014d; SKM 2010b)

3.1.2.2 Nutrients

Waterways of the Loddon River catchment have a history of high levels of nutrients from both point and diffuse sources. High nutrient levels have resulted in blue-green algal blooms in the majority of storages and water bodies in the catchment over time including Cairn Curran, Tullaroop and Laanecoorie. In the 1990s the Loddon catchment recorded the highest incidence of blue-green algal blooms in Victoria (North Central CMA 2003). Blue Green algal blooms are common in the upstream storages (GMW 2013; GMW 2015c).

3.1.2.3 Temperature

The status of water temperature downstream of Cairn Curran, Tullaroop and Laanecoorie Reservoirs is uncertain. It has been suggested these reservoirs may release colder than natural water but further investigation is required.

3.1.2.4 Dissolved oxygen

Dissolved oxygen concentrations have been recorded at potentially dangerous levels for aquatic biota in Tullaroop Creek and immediately downstream of Loddon Weir when flow drops below approximately 5 ML/day. However, there are no known reports of widespread fish kills associated with low dissolved oxygen under very low flow conditions in these reaches (Jacobs 2015a).

Very low dissolved oxygen concentrations have been recorded at higher flows in the reach between Loddon Weir and Twelve Mile Creek but those records may be associated with hypoxic blackwater events (Jacobs 2015a)

3.1.2.5 Hypoxic Blackwater Events

Blackwater events are a natural feature of floodplain systems and events that discolour the water without severely depleting oxygen concentrations are of no consequence. Moreover, high flows that regularly wash leaf litter and other organic matter into the river system are needed to provide a carbon source (i.e. food and energy) for riverine foodwebs. Without a regular supply of leaf litter, the abundance of macroinvertebrates, fish, Platypus and other consumers in the Loddon River will decline. The only blackwater events of concern are those that create hypoxic conditions and kill fish and other aquatic biota.

Hypoxic blackwater events occur when large amounts of carbon are leached from leaf litter and other organic matter that has been recently inundated. The leached carbon turns the water black and the microbes that live in the sediments consume the dissolved organic carbon and oxygen from the water. Not all blackwater events pose a risk to aquatic ecology however if the rates of leaching and microbial activity are both high, then oxygen levels can become depleted to such an extent that fish and other aquatic biota are not able to survive and in severe cases, widespread fish deaths can occur.

Three hypoxic blackwater events occurred between 2004 and 2006 downstream of Loddon Weir in Reaches 4a, b and c which occurred as result of the build-up of large amounts of leaf litter and organic matter followed by summer flows of short duration (SKM 2008).

3.1.2.6 Acidity

During the Millennium Drought, Reach 4a was dry and was exhibiting evidence of acidification, such as oxidised iron staining and low pH in pools of water and sediment. Two possible options were hypothesised including presence of Potential Acid Sulfate Soils (PASS) or intrusion of acidic groundwater (SKM2010b; SKM 2010c). The 2010-11 floods water volumes were so great that any acidification upon rewetting was diluted, which eliminated the risk at that time and given that improved agricultural practices have lowered groundwater levels in the mid Loddon River System, the risk of ASS forming in the foreseeable future is low (Jacobs 2015a).

3.2 Streamflow

Discharge is measured in the Loddon system at a number of established gauging stations (Table 7). There is very little stream flow information for Serpentine Creek however GMW SCADA information can be used to provide some level of information.

Table 7: Stream flow gauging stations in the Loddon system

Station ID	Type of monitoring station	Location	Parameters monitored	Period of Record
Upper system				
407241	Major storages	Cairn Curran Reservoir Head Gauge	Level Water quality	1992 to current
407210	VWQMN[5]	Loddon River d/s Cairn Curran	Flow	1943 to current
407248	Major storages	Tullaroop Reservoir outlet weir	Flow	1960 to current
407244	Major storages	Tullaroop Reservoir Head Gauge	Flow Water quality (to 2009)	1960 to current
407240	Major storages	Laanecoorie Reservoir Head gauge	Flow Water quality (to 2009)	1997 to current
407203	VWQMN	Loddon d/s Laanecoorie Reservoir	Flow Water quality T^0 EC	1891 to current
Mid system				
407229	VWQMN	Loddon River d/s Serpentine Weir	Flow Water quality T^0 EC	1976 to current
407224		Loddon River d/s Loddon Weir	Flow	1976 to current
407205	VWQMN	Loddon River at Appin South	Flow Water quality T^0 EC	1946 to current
407289	GMW	Nine Mile Creek at Serpentine Creek offtake	Flow T^0 EC	1990 to current
407285	GMW	Nine Mile Creek at Coads Rd	Flow T^0 EC	1998 to current
Lower system				
407202	VWQMN	Loddon River d/s Kerang Weir	Flow Water quality T^0 EC	1951 to current
407293	GMW	Box Creek d/s Kow swamp regulator	Flow T^0 EC	1992 to current
407295	GMW	Box Creek @ Mansfields Bridge	Flow T^0 EC	1992 to current
407294	GMW	Pyramid Creek @ Flannerys Bridge	Flow T^0 EC	1992 to current
Sourced from *Water Measurement Information System* (DELWP 2015b)				

[5] Victorian Water Quality Monitoring Partnership (VWQMP).

3.3 System operation

The Loddon River water supply system forms part of the Goulburn Murray Irrigation District (GMID) with Cairn Curran, Tullaroop and Laanecoorie reservoirs and Bridgewater, Serpentine, Loddon and Kerang weirs all operated to regulate flows in the Loddon River (Figure 4).

The capacities of the Loddon River storages are:

- Cairn Curran Reservoir has a capacity of 147,000 ML
- Tullaroop Reservoir has a capacity of 73,000 ML
- Laanecoorie Reservoir originally had a capacity of 20,000 ML now has a capacity of 8,000 ML due to sedimentation of the reservoir
- Kow Swamp has a capacity of 51,000 ML

Other weirs, regulators and structures that influence the operation of the Loddon River System include:

Reach number	Structure Name	Function
Upper Loddon River		
3a	Bridgewater Weir	Is a low level weir with a fixed sill and while it impounds flows it has no regulatory function.
3a-3b S1	Serpentine Weir	Diverts Loddon River flows downstream (from reach 3a) to Serpentine Creek to supply diverters and supplement supplies to the Loddon Valley Irrigation Area. Allows passing flows into reach 3b.
Mid Loddon River		
S2-S3	No. 2 Regulator	Regulates inflows from Reach S1 and The Waranga Western Channel Bears Lagoon crosses and diverts water to Serpentine Creek at the. Water is diverted to Channel 1/12 which re-enters Serpentine Creek at the Durham Ox weir pool
S4	No. 12 Regulator	Regulates irrigation water to the No. 12 channel
S4	Pennyroyal Outfall	Controls the water level in the Durham Ox weir pool and provides flood releases
S4	Nine Mile Creek Outfall	The Nine Mile Creek outfall is not currently operational due to outdated infrastructure. There is the potential to upgrade the drop board structure to facilitate delivery of water to high environmental values downstream.
R3b-R4a	Loddon Weir	Diverts water from the upper Loddon River and the Waranga Western Channel to supply the Boort section of the Loddon Valley Irrigation Area.
R4a-R4b	Twelve Mile Regulator	Controls low flows in the Loddon with the capacity to split flows between Twelve Mile Creek and the main stem of the Loddon River. In 2015 the regulator is non-functioning and its future as an operable structure is unclear. It is likely to be replaced with a low level fixed sill weir
R4c	The Chute	A passive structure consisting of a pipe culvert embedded in an earthen bank that constricts flows in the Loddon River just downstream from the diffluence of Wandella Creek. It allows low flows to pass down the Loddon whilst high flows are backed up and flow down Wandella Creek and hence to Leaghur Forest. The Chute is scheduled to be replaced in 2015 by a vertical slot fishway.
R4d	Macorna Channel Siphon	Siphons inflows from Kow Swamp under the Loddon River upstream of Kerang and has a regulator which can release water into the Loddon. Until the 1990s this was used to direct water down the Loddon to supplement urban water supply for Kerang township. This is no longer the case and most outfall from the channel is from rainfall rejection spills (SKM 2010b).
Lower Loddon River		
R4d – R5	Kerang Weir	Controls flows from the Loddon River and from Pyramid Creek. Water can be diverted from the Kerang Weir pool towards the Kerang Lakes via Washpen Creek or directed to flow into reach 5 of the Loddon River. When the water level in the Kerang weir pool reaches 75.65m AHD Sheepwash Creek engages.
R5-LMR	Fish Point Weir	Controls flows from R5 into the western arm of the Little Murray River.

Regulation has diverted approximately 40% of stream flow for consumptive use (LREFSP 2002b). The total volume of water available for allocation and the total volume used in 2012/13 for the entire Loddon basin is shown in Table 8 (DEPI 2014b). The volume stated is inclusive of storages in the upper Loddon River System which are outside the scope of this EWMP. The estimated volume of water harvested from small catchment dams for the 2012/13 year is 79,616 ML. This includes unlicensed stock and domestic dams and registered commercial and irrigation dams and represents the largest diversion of surface water in the Loddon basin (DEPI 2014b).

Table 8: Summary of total Loddon basin water resources available for allocation in 2012/13

Water source	Total water resource (ML)	Total use (ML)
Surface water	210,953	115,983
Groundwater	62,661	24,588
Recycled water	7,746	2,775
Sourced from *Victorian Water Accounts* (DEPI 2014b)		

3.4 Environmental watering

Environmental flow recommendations for the Loddon River were first developed in 2002 for reaches 1 to 5 (LREFSP 2002a) and were used to inform the development of the Bulk Entitlement (Loddon River – Environmental Reserve) Order 2005. These recommendations were revised in 2010 to account for improved understanding of the river hydrology downstream of Loddon Weir and changed environmental conditions in the lower Loddon, to include Twelve Mile Creek and refine the flow recommendations (SKM 2010c). Over the last ten years the North Central CMA has aimed to deliver environmental water against these flow recommendations.

Appendix 2 provides an overview of the achievement of environmental flow recommendations from 2004 to 2014. During the Millennium Drought, Qualifications of Rights were issued by the Victorian Minister for Water between 2007 and 2010 which modified the obligation to release environmental flows and resulted in extended cease to flow periods in the system (GMW 2010). An increase in the volume of water held in storage, coupled with increased environmental entitlements held by both VEWH and CEWH for the Loddon River System have enabled the North Central CMA to deliver the majority of the environmental flow recommendations for Reach 4.

The *2015-16 Loddon River System Seasonal Watering Proposal* included flow recommendations from the Loddon River Flows update and the Pyramid and Serpentine Creek flows studies (Jacobs 2014b; Jacobs 2014g; Jacobs 2015a). Management of Reach 5 was included for the first time in the annual seasonal watering proposal for the Loddon River in 2015/16.

4 System values

4.1 Water dependent environmental values

The Loddon River supports a wide variety of water dependent flora and fauna. Detail on significant water dependent environmental values are described in detail in Sections 4.1.1 and 4.1.2. A full species list is provided in Appendix 5: Species List.

The upper Loddon River System has high ecological value due to the diversity of flora and fauna values it supports. The local communities particularly value the native fish and Platypus populations as well as the aesthetic and recreational values of the river (Jacobs 2015a). Table 9 details the legislation, agreements, conventions and listings that are relevant to species found in the Loddon River System.

Table 9: Legislation, agreements, convention and listings relevant to the site or species recorded in the upper Loddon River System

Legislation, Agreement or Convention	Jurisdiction	R1	R2	R3a	R3b	Serp	R4	R5	Pyr
Japan Australia Migratory Birds Agreement (JAMBA)	International	✓					✓	✓	✓
China Australia Migratory Birds Agreement (CAMBA)	International	✓						✓	✓
Korea Australia Migratory Birds Agreement (ROKAMBA)	International								✓
Convention on the Conservation of Migratory Species of Wild Animals (Bonn Convention)	International								✓
Environmental Protection and Biodiversity Conservation Act 1999 (EPBC Act)	National	✓	✓	✓	✓		✓	✓	✓
Flora and Fauna Guarantee Act 1988 (FFG Act)	State	✓	✓	✓	✓	✓	✓	✓	✓
DEPI advisory lists	State	✓	✓	✓	✓	✓	✓	✓	✓
R1, R2, R3a, R3b, Serp, R4, R5, Pyr: Reach 1, Reach 2, Reach 3a, Reach 3b, Serpentine Creek, Reach 4, Reach 5, Pyramid Creek									

4.1.1 Fauna

4.1.1.1 Fish

One native fish species complex and eight native fish species of conservation significance have been recorded in the Loddon River System (Table 10). Silver Perch (*Bidyanus bidyanus*), listed as critically endangered under the *EPBC Act 1999*, has been recorded in the mid and lower Loddon River System. This species is not stocked and its presence in these reaches is likely due to fish passage at Kerang Weir, which provides critical connection between reaches 4 and 5 of the Loddon River, Pyramid Creek and the Murray River. The 2015 VEFMAP fish survey captured one individual in Reach 3a (Serpentine Weir pool), analysis has not been completed for the 2015 VEFMAP fish survey, however it is possible that this individual entered Reach 3a during the 2011 floods.

Murray Cod (*Maccullochella peelii*), listed as endangered under the *EPBC Act 1999*, has been recorded in all reaches of the impounded upper Loddon River in (reaches 1 to 3b) as well as Reach 5 of the Loddon River and Pyramid Creek (Jacobs 2014d). There are no recent records of this species in the mid Loddon River. This species is stocked in the upper Loddon River annually, however the presence of large animals in the impoundments of the Loddon is indicative that suitable habitat is present (Jacobs 2014f).

Macquarie Perch (*Macquaria australasica*), listed as endangered under the EPBC Act, has been recorded in the upper Loddon River System, however it has not been recorded since 1995. Its current distribution is unknown.

Significant numbers of FFG-listed Murray-Darling Rainbowfish (*Melanotaenia fluviatilis*), were recently recorded in reaches 3a, 3b, 4, 5 and Pyramid Creek with a wide distribution (captured at multiple sites in each reach in the 2014 VEFMAP surveys. This small bodied species has been absent from previous fish surveys and was presumed lost from the river (Jacobs 2014f). It is possible that this species entered the impounded reaches (3a and 3b) during the 2010-11 floods (Jacobs 2014f).

FFG-listed Freshwater Catfish (*Tandanus tandanus*) was historically recorded in Reach 1 of the Loddon River. Reach 1 was considered a low priority for fish monitoring due to lack of good quality instream habitat when the monitoring design for VEFMAP in the Loddon River was developed (SKM 2007) therefore the current status of Freshwater Catfish in this reach is unknown.

Individuals from the Mountain Galaxias (*Galaxias olidus*) complex have been recorded in Reach 2. This complex of 15 species has recently been determined from what was once considered a single species (Raadik 2011). The actual species' of Mountain Galaxias in the upper Loddon River System needs to be identified in future fish surveys as seven of the species have either been listed or nominated under the *FFG Act* (DEPI 2013b).

The conservation status of near threatened for Golden Perch (*Macquaria ambigua*) is only relevant for natural populations (DEPI 2013b). This species has been recorded in every reach of the Loddon River, however it is actively stocked (DEPI 2014c). The recent VEFMAP surveys did not detect calcein dye (used to mark stocked individuals) on many captured individuals and a number of small (juvenile) Golden Perch have been captured, however it is not always possible to detect calcein dye when it is present therefore it is prudent not to make inferences to the Golden Perch population in the Loddon River being natural without further research (Jacobs 2014f).

Although not listed under any legislation, River Blackfish (*Gadopsis marmoratus*), which is considered regionally significant, has regularly been captured (albeit in small numbers) in Tullaroop Creek (Reach 2) and in Serpentine Creek (Jacobs 2014f). These two populations are fragmented and isolated by instream barriers (Jacobs 2014d). Anecdotally this species was a very popular angling species and was once abundant throughout the Loddon River System (Appendix 1: Loddon River EWMP Consultation).

Other than the Mountain Galaxias complex, all of the significant fish species recorded in the Loddon River are listed under the FFG *Lowland Riverine Fish Community of the Southern Murray-Darling Basin*. Historically this community was dispersed throughout the lowland areas of the Victorian Murray River system but anthropogenic change and introduced fish species has altered this distribution and abundance (SAC 1998). The Loddon River supports thirteen fish species in this ecological community (Appendix 5: Species List).

4.1.1.2 Waterbirds

Twenty-six waterbirds have been recorded in the Loddon River System. The vast majority of these records are for Pyramid Creek. It is likely that these records are from Hird and Johnson swamps (located on the creek line), which are valued for their high waterbird carrying capacity (Table 10). Anecdot5ally the majority of the significant bird species listed in Table 10 have been sighted on the Kerang Weir pool (Jones, E 2015, personal communication, [landholder Loddon River], 2 June). The source for waterbird records is the Victorian Biodiversity Atlas (VBA) which records presence only and does not describe what these water dependent species were using the river or creeks for (e.g. breeding). It should be noted that active surveys have not been conducted for waterbirds and therefore the significance of the river for threatened species is relatively unknown.

4.1.1.3 Reptiles

Records for freshwater turtles in the Loddon River are scarce as active surveys for freshwater turtles have not occurred. The Eastern Long-necked Turtle (*Chelodina longicollis)* has been recorded as incidental by-catch in the VEFMAP surveys in Reach 2. This species has recently been listed on the Victorian *Advisory List of Threatened Vertebrate Fauna in Victoria* as data deficient. The Murray River Turtle (*Emydura macquarii)* and Eastern Long-necked Turtle were observed in Serpentine Creek during site visits in 2014 (Rogers, L 2014, personal observation, [North Central CMA Project Manager], February & April). These species are listed on the Victorian *Advisory List of Threatened Vertebrate Fauna in Victoria* as vulnerable and data deficient respectively. Anecdotal evidence (Appendix 1: Loddon River EWMP Consultation) suggests that freshwater turtles (species unknown) were once prolific throughout the Loddon River System but that numbers have declined in recent years (Hall, B 2015, personal communication, [Pyramid Creek landholder], April). This aligns with findings throughout Murray-Darling Basin (Spencer, R 2013, personal communication, [University of Western Sydney], 24 September). Research is occurring on freshwater turtle populations across the Murray-Darling Basin as population levels for all species are declining, predominantly due to nest predation and lack of recruitment (Spencer, R 2013, personal communication, [University of Western Sydney], 24 September).

4.1.1.4 Mammals

Although not listed under legislation or Victoria's advisory lists, the national conservation status of Platypus (*Ornithorhynchus anatinus*) has recently been elevated to near threatened (CSIRO 2014) which is recognition of the fact that Platypus numbers have been declining in many areas over the last few decades, particularly during the Millennium Drought, and that the species has already disappeared from some catchments (Serena, M 2014, personal communication [Australian Platypus Conservancy], July). To date Platypus live-trapping surveys have not been conducted along the Loddon River (Jacobs 2015a). Knowledge of Platypus distribution and status has been derived based on sightings and Platypus capture as by-catch during fish surveys. Based on qualitative data (i.e. regularity of sightings), the reaches in the upper Loddon River System and Serpentine Creek are likely to support a viable breeding population (Jacobs 2015a; Jacobs 2014d). The mid Loddon River main stem and Twelve Mile Creek are likely to provide habitat (i.e. food resources) and act as a corridor for juveniles dispersing from the upper Loddon River System to the lower Loddon River System and the Murray River, with the exception of the Kerang Weir pool, which is likely to support resident Platypus (Jacobs 2015a). Platypus have not been regularly sighted in the lower Loddon River System, however, given that Platypus are known to occupy Kerang Weir pool and the Little Murray anabranch system into at least the early 2000s, it is likely that Platypus would use Reach 5 (Jacobs 2015a).

4.1.1.5 Frogs

One significant and six common frog species have been recorded in the Loddon River System (Appendix 5: Species List). Targeted frog surveys have not been undertaken so this list is not exhaustive. EPBC-listed Growling Grass Frog (*Litoria raniformis*) has been recorded at Pyramid Creek, however as with the waterbird records, this record is likely to align with Hird and Johnson swamps. The lower Loddon River floodplain (near Benjeroop) is known to have supported a meta population of this nationally threatened species (Smith et al. 2008), however recent surveys have shown that numbers have drastically declined since the Millennium Drought (SKM 2014a).

Table 10: Significant fauna species recorded in the Loddon River System

Common Name	Scientific Name	R1	R2	R3a	R3b	R4	Serp	R5	Pyr	Int'n Status	EPBC status	FFG status	Vic status	Last record
Native fish														
Silver Perch	*Bidyanus bidyanus*					✓		✓	✓	-	CR	L	VU	2015
Macquarie Perch	*Macquaria australasica*	✓	✓	✓						-	EN	L	EN	1995
Murray Cod	*Maccullochella peelii*	✓	✓	✓	✓			✓	✓	-	VU	L	VU	2014
Freshwater Catfish	*Tandanus tandanus*	✓								-		L	EN	2004
Murray-Darling Rainbowfish	*Melanotaenia fluviatilis*			✓	✓	✓		✓	✓	-		L	VU	2014
Mountain Galaxias*	*Galaxias olidus*		✓							-		L		2002
Unspecked Hardyhead	*Craterocephalus fulvus*								✓	-		L		2014
Golden Perch	*Macquaria ambigua*	✓	✓	✓	✓	✓	✓	✓	✓	-			NT	2014
River Blackfish	*Gadopsis marmoratus*		✓				✓			-			DD	2014
Waterbirds														
Painted Snipe	*Rostratula australis*								✓	C	EN	L	CR	2004
White-bellied Sea-Eagle	*Haliaeetus leucogaster*								✓	C		L	VU	2007
Glossy Ibis	*Plegadis falcinellus*								✓	C/B			NT	2004
Eastern Great Egret	*Ardea modesta*	✓				✓		✓	✓	C/J		L	VU	2004
Caspian Tern	*Hydroprogne caspia*								✓	J/C		L	NT	2005
Common Greenshank	*Tringa nebularia*								✓	J/C/R/B			VU	2004
Marsh Sandpiper	*Tringa stagnatilis*								✓	J/C/R/B			VU	2004
Blue-billed Duck	*Oxyura australis*								✓			L	EN	1993
Brolga	*Grus rubicunda*						✓		✓			L	VU	1984
Freckled Duck	*Stictonetta naevosa*								✓			L	EN	2004
Grey-crowned Babbler	*Pomatostomus temporalis temporalis*								✓			L	EN	2006
Intermediate Egret	*Ardea intermedia*					✓						L	EN	2001
Little Bittern	*Ixobrychus dubius*								✓			L	EN	2006
Little Egret	*Egretta garzetta nigripes*								✓			L	EN	1961

Common Name	Scientific Name	R1	R2	R3a	R3b	R4	Serp	R5	Pyr	Int'n Status	EPBC status	FFG status	Vic status	Last record
Magpie Goose	*Anseranas semipalmata*					✓						L	NT	2003
Lathams Snipe	*Gallinago hardwickii*					✓						N	NT	1998
Australasian Shoveler	*Anas rhynchotis*								✓				VU	2005
Hardhead	*Aythya australis*								✓				VU	2005
Marsh Sandpiper	*Tringa stagnatilis*					✓							VU	1992
Musk Duck	*Biziura lobata*								✓				VU	2005
Nankeen Night Heron	*Nycticorax caledonicus hillii*	✓		✓					✓				NT	2011
Pacific Golden Plover	*Pluvialis fulva*							✓					VU	2012
Pied Cormorant	*Phalacrocorax varius*								✓				NT	2007
Red-backed Kingfisher	*Todiramphus pyrropygia pyrropygia*								✓				NT	1999
Royal Spoonbill	*Platalea regia*				✓	✓		✓	✓				NT	2006
Whiskered Tern	*Chlidonias hybridus javanicus*								✓				NT	2004
Reptiles														
Murray-River Turtle	*Emydura macquarii*						✓			-			VU	2014
Eastern Long-necked Turtle	*Cheoldina longicollis*		✓				✓			-			DD	2014
Frogs														
Growling Grass Frog	*Litoria raniformis*										EN	L	EN	1982

Legend -

R1, R2, R3a, R3b, R4, Serp, R5, Pyr: Reach 1, Reach 2, Reach 3a, Reach 3b, Reach 4, Serpentine Creek, Reach 5, Pyramid Creek

✓**:** recorded

* - Recent taxonomic research has recognised that *Galaxias olidus* is actually several separate species. As at March 2015 the conservation status of the species is still being determined

Int'n (International) Status: C – CAMBA, J – JAMBA, R – ROKAMBA, B – Bonn Ceonvention

EPBC status: Endangered,Vulnerable

FFG status: Listed as threatened,

Vic Status: CRitically endangered, ENdangered, VUlnerable, Near Threatened, Data Deficient

Source: DEPI, 2015 (VBA); SKM (2014); Birdlife Australia (2014)

4.1.2 Vegetation communities and flora

The vegetation communities of the Loddon River System are restricted to a relatively narrow riparian zone that rarely extends into the floodplain beyond the crest of the river bank, with the exception of some areas of public land in the upper and lower Loddon and lower lying floodplain areas that extend into the floodplain for several hundred metres in the mid Loddon (Jacobs 2015a).

The dominant riparian Ecological Vegetation Class (EVC) for the upper Loddon River (Reaches 1, 3a and 3b), and the mid Loddon (Reaches 4a, 4c, 4d and Serpentine Creek) is the Floodplain Riparian Woodland (EVC 56) (Table 11), which is endangered in the Victorian Volcanic Plain and Central Goldfield bioregions and vulnerable in the Victorian Riverina Bioregion. The benchmark for this EVC is characterised by River Red Gum (*Eucalyptus camaldulensis*) as the dominant canopy species over a medium to tall shrub layer with a ground layer consisting of amphibious and aquatic herbs and sedges (DSE 2004a). Along Reach 1 and Reach 3a this EVC is characterised by a mature River Red Gum canopy with a mixture of shrubs (e.g. *Callistemon* spp.) and a mix of native and exotic grasses, although areas with cattle access generally have lower vegetation cover (Jacobs 2015a ; SKM 2014b). Along Reach 4, this EVC is represented by a mixed aged River Red Gum canopy, although the majority of trees are young (with trunks less than 40cm DBH) (SKM 2014b). The understory is a mixture of shrubs and grasses, although, as with the upper Loddon River, areas with cattle access generally have lower vegetation cover (Jacobs 2015a ; SKM 2014b). Serpentine Creek has an almost continuous cover of River Red Gum lining its banks at widths from 5 to 40 m wide however the understorey is largely sparse or missing (Jacobs 2014d).

The dominant riparian EVC along Tullaroop Creek (Reach 2) is endangered Creekline Grassy Woodland (EVC 68). This EVC is characterised by River Red Gum dominated canopy with occasional scattered shrub layer over a mostly grassy/sedgy to herbaceous ground-layer (DSE 2004a). In Reach 2 this EVC is characterised by mixed age River Red Gum canopy over grassy (non-native) understorey (Jacobs 2015a ; SKM 2014b). Section 5 provides detail on the condition of vegetation communities.

The primary EVC on the river terraces or low lying floodplain of the mid-Loddon River System, including the entire length of Twelve Mile Creek, is Grassy Riverine Forest/Riverine Swamp Forest Complex (EVC 812) (Table 11) (DELWP 2015a). This EVC complex is River Red Gum dominated with understorey consisting of flood tolerant grasses on higher elevations or flood dependent sedges and rushes in flood prone areas (Jacobs 2015a; DSE 2004a; SKM 2010b).

Along lower sections of Reach 4d and Serpentine Creek the riparian vegetation is transitions from Floodplain Riparian Woodland to Lignum Swampy Woodland (EVC 823). This EVC continues along Reach 5 downstream of Kerang Weir to the confluence of Barr Creek. This EVC is also present along Pyramid Creek from about Hird Swamp to its confluence with the Loddon at Kerang (Jacobs 2014e). This EVC is dominated by a Tangled Lignum (*Duma florulenta*) understory. At the transition zone between Floodplain Riparian Woodland and Lignum Swampy Woodland in Reach 4, the overstory comprises a mix of River Red Gum and Black Box (*Eucalyptus largiflorens*) (Jacobs 2015a), whereas Pyramid Creek and downstream of Kerang Weir, this EVC is dominated by a Black Box (*Eucalyptus largiflorens*) overstory (DSE 2004a). The understorey of Tangled Lignum along Reach 5 has become extremely dense, and SKM (2014b) states that in some areas it was bordering on impassable. This aligns with community observations that the Tangled Lignum is so dense that it is excluding all other vegetation (Myers, C 2015, personal communication, [Landholder with Loddon River frontage], 19 March). A narrow band of River Red Gum is located along the bank of Reach 5 at the water's edge. Most of these River Red Gum trees are thought to be less than 100 years old and are a likely consequence of irrigation water bringing seeds into the system (Jacobs 2015a)

From Barr Creek toward the Murray River the riparian EVC is Grassy Riverine Forest/ Riverine Swamp Forest Complex (EVC 812) and is once again dominated by a River Red Gum overstory along the channel with an understorey consisting of flood tolerant grasses on higher elevations or flood dependent sedges and rushes in flood prone areas (DSE 2004; Rogers, L 2015, personal observation, [North Central CMA], 4 March; SKM 2010a).

Vegetation communities along Pyramid Creek upstream of Hird Swamp are largely absent. Small stands of Lignum Swamp (EVC 104) persist along sections of the creek where stock access has been restricted which is dominated by Tangled Lignum with very few trees (Jacobs 2014e).

Table 11: Vegetation communities (EVCs) and bioregional conservation status for the Loddon River System

Bioregion	EVC Name	EVC #	Bioregional Conservation Status
Reach 1			
Goldfields	Floodplain Riparian Woodland	56	Endangered
Victorian Volcanic Plain	Floodplain Riparian Woodland	56	Endangered
Reach 2			
Goldfields	Creekline Grassy Woodland	68	Endangered
Victorian Volcanic Plain	Creekline Grassy Woodland	68	Endangered
Reach 3a			
Goldfields	Floodplain Riparian Woodland	56	Endangered
Victorian Riverina	Floodplain Riparian Woodland	56	Vulnerable
Reach 3b			
Victorian Riverina	Floodplain Riparian Woodland	56	Vulnerable
Serpentine Creek			
Victorian Riverina	Floodplain Riparian Woodland	56	Vulnerable
	Grassy Riverine Forest/Riverine Swamp Forest Complex	812	Depleted
	Lignum Swampy Woodland	823	Vulnerable
Reach 4a,4c and 4d– Loddon Main Stem			
Victorian Riverina	Floodplain Riparian Woodland	56	Vulnerable
	Grassy Riverine Forest/Riverine Swamp Forest Complex	812	Depleted
	Lignum Swampy Woodland	823	Vulnerable
Reach 4b – Twelve Mile Creek			
Victorian Riverina	Grassy Riverine Forest/Riverine Swamp Forest Complex	812	Depleted
Reach 5			
Murray Fans	Lignum Swampy Woodland	823	Vulnerable
Murray Fans	Riverine Grassy Woodland	295	Vulnerable
Murray Fans	Grassy Riverine Forest/Riverine Swamp Forest	812	Depleted
Pyramid Creek			
Murray Fans	Lignum Swampy Woodland	823	Vulnerable
Victorian Bioregion	Lignum Swamp	104	Vulnerable
	Lignum Swampy Woodland	823	Vulnerable
Source: DELWP 2015c			

Aquatic instream vegetation, such as Water Ribbons (*Triglochin* spp.) and Marshwort (*Potamogeton* spp.), and emergent non-woody vegetation (such as Common Reed (*Phragmites australis*), clubrushes and clubsedges (*Bolboschoenus* spp. and *Schoenoplectus* spp.), persist along the upper Loddon River with varying degrees of coverage (Jacobs 2015a).

There is very little instream and emergent vegetation evident in the mid Loddon River channel downstream of Loddon Weir, both in Twelve Mile Creek and the Loddon main stem. Species such as Common Reed (*Phragmites australis*), *Bolboschoenus* spp. *Juncus* spp. persist in small stands (Jacobs 2015a). Conversely, Serpentine Creek supports a significant coverage of high quality instream vegetation (Jacobs 2014d). supporting flora from genus' such as *Carex* spp. and *Eleocharis* spp. (Jacobs 2014d). Pyramid Creek and Reach 5 have very limited instream aquatic vegetation. Emergent vegetation is dominated by Tangled Lignum and

Common Reed, with some sedges and rushes downstream of Barr Creek.

Five significant water dependent flora species have been recorded in Loddon River System and are shown in Table 12.

Table 12: Significant water dependent or water tolerant flora species recorded in the Loddon River System

Common Name	Scientific Name	R1	R2	R3a	Serp	EPBC status	FFG status	Vic Status	Date last record
Bluish Raspwort	*Haloragis glauca f. glauca*			✓				k	2012
Plains Joyweed	*Alternanthera sp. 1 (Plains)*			✓				k	2012
Tall Club-sedge	*Bolboschoenus fluviatilis*		✓					k	1997
Branching Groundsel	*Senecio cunninghamii var. cunninghamii*				✓			r	1999
Pale Spike-sedge	*Eleocharis pallens*				✓			k	1996
Legend: **Vic Status:** r – rare; k- poorly known									
Source: DEPI (2014d)									

4.1.3 Habitat

Additional to the habitat that flora and vegetation communities provide, the Loddon River System also has high instream woody habitat (IWH) values. IWH reinstatement works have occurred in Reaches 1 and 2 and Pyramid Creek (North Central CMA 2015a). Recent surveys indicate a medium to high level of IWH located at VEFMAP sites (LREFSP 2002b; SKM 2014b). Reach 2 in particular has high levels of historical IWH (SKM 2014b) and coarse IWH is abundant in Serpentine Creek (Jacobs 2014d). This is a critical habitat component for River Blackfish that requires hollow snags as a substrate for spawning (Jacobs 2015a). All reaches of the mid Loddon River have a significant amount of high quality complex IWH located throughout the channel (Kitchingman et al. 2012; Jacobs 2014d; SKM 2010b; SKM 2014b). Reach 5 has a history of “de-snagging” and although large volumes of IWH is located higher on the banks in Reach 5, very little IWH is located in the channel (SKM 2014b).

The upper Loddon River System is characterised by a number of deep pools, particularly in reaches 2 and 3a (LREFSP 2002b; SKM 2013). Anecdotally a number of deep pools in Reach 2 continued to hold water throughout the Millennium Drought under continued cease-to-flow events (Teese, A 2015, personal communication, [Tullaroop Creek landholder], 28 January). These provide critical drought refuge to aquatic flora and fauna during periods of low to no flow. Some deep pools are located in reaches 4a and 4 d, however the sediment has infilled the majority of the deep pools in reaches 4b (Twelve Mile Creek) and 4c (Jacobs 2015a; SKM 2010b). The presence of deep pools in Reach 5 is a knowledge gap. Community advice is that some silt was scoured from pools during the 2011 floods a few kilometres downstream of the Kerang Weir (Hall, B 2015, personal communication, [local community], 29 January). As discussed in Section 2.2.2, Pyramid Creek was dredged in the 1960s and as such all run/riffle pool structure has been destroyed (Jacobs 2014e).

4.2 Social

The Loddon River System has significant social valueto the community that live within the Loddon River catchment. There are approximately 20 Landcare groups that operate or have historically operated in Loddon River System area (Table 13).

Table 13: Landcare Groups in the Loddon River System EWMP area

Benjeroop	Murrabit	Lake Charm
Kerang	Macorna	Canary Island*
Appin / Leaghur	Yando	Loddon Vale*
Kinypanial	Jarklin	Calivil
East Loddon*	Salisbury West*	West Marong#
Laanecoorie	Eddington#	Baringhup
Moolort	Mid Loddon Conservation Management Network	
* linked through the Loddon Plains Landcare Network # linked through the Mid Loddon Landcare Network		

4.2.1 Cultural heritage

The Loddon River and floodplains were significant to the original inhabitants, the Dja Dja Wurrung, Barapa Barapa and Wamba Wamba Traditional Owners, and would have provided them with a rich source of food and materials. Kow Swamp is a site of cultural significance to the Yorta Yorta Traditional Owners. The Loddon River region contains a richness of Aboriginal cultural artefacts including middens, cooking mounds, stone scatters and stone tools. Bark canoes played an important part of traditional life on the Loddon plains and wetlands and Lake Boort has the most significant number of scarred trees in Victoria (Haw & Munro 2010). There are multiple sites of cultural significance located within the Loddon River System. These include scarred trees, rock art and oven mounds, and some human remains (North Central CMA 2015a).

The Loddon River System has a long history of European and Chinese settlement, with the upper Loddon River System located in the Central Goldfields claimed as the richest alluvial goldfield in the world which in the latter 1800's was home to tens of thousands of minors and their families (Parks Victoria 2013). The Loddon Plains were settled by squatters from the 1840s and small scale irrigation beginning in 1850 with the excavation of Blackfellows Cutting to divert water from the Loddon to Lake Boort by Fredrick Godfrey (Haw & Munro 2010). Many relics, such as ruins of buildings and infrastructure to move water, throughout the Loddon System have high cultural heritage value.

4.2.2 Recreation

The Loddon River is a valuable recreation area in the North Central CMA region and has high passive recreation values. Recreational fishing is rated as very high for upper Loddon and Serpentine Creek. Laanecoorie Reservoir and Reach 3a are stocked (Fisheries) with Murray Cod and Golden Perch and Serpentine Creek is stocked with Golden Perch annually (DEPI 2014c).

Other recreational values that are rated as very high include waterskiing, boating, swimming, canoeing and walking along riverside tracks.

4.3 Economic

There are valuable and highly productive irrigation areas in the Loddon-Murray area with comprising dairy, pasture and irrigated horticulture. Mixed farming and cereal growing dominate the mid and upper catchment. Relatively small areas of intensive horticulture exist upstream of Laanecoorie reservoir in the upper catchment also generate substantial wealth (North Central CMA 2006).

4.4 Ecosystem functions

'Ecosystem function' is the term used to define the biological, geochemical and physical processes and components that take place or occur within an ecosystem. Ecosystem functions relate to the structural components of an ecosystem (e.g. vegetation, water, soil, atmosphere and biota) and how they interact with each other, within ecosystems and across ecosystems (Maynard et al. 2012). Ecosystem functions critical to support the primary water dependent environmental values of the Loddon River System include (but are not limited to):

- Food production – a critical ecosystem function is the conversion of matter to energy for uptake by biota. Structural components include substrate surfaces (e.g. IWH, rocks and gravel) for biofilms, and plant matter. Terrestrial carbon inputs (e.g. leaf litter) from river banks, and where feasible, the floodplain into the channel are critical. Interactions between primary producers and consumers such as zooplankton and macroinvertebrates break down the carbon and nutrients required for higher order consumers.
- Reproduction – recruitment of new individuals is important for the river's primary values, native fish, platypus and River Red Gum trees. Fish require nursery habitats such as slackwater areas to provide suitable conditions for native fish larvae metamorphosis (linked to food web function).

  Breeding is required in most years for small bodied fish in particular, and given the reduced number of large bodied fish in the system it is recommended that conditions suitable for spawning of large bodied fish, such as Murray Cod, are provided in most years (Jacobs 2015a).

  Platypus live for approximately 15 years on average and reach sexual maturity at 2-3 years. Females lay their eggs in nesting burrows that have an entrance near the water, but then extend several metres up the bank to reduce the risk of flooding. Juveniles first emerge from their burrows in mid to late summer and leave the nest between April and June. They have 1-2 offspring each season, but only successfully breed when food is abundant because lactating females need to consume up to 80% of their bodyweight each day (Jacobs 2015a).

River Red Gum trees require high flows in spring to facilitate germination events. Follow up watering is required in a second year to water germinated saplings. Due to the long lived nature of this species recruitment events are only required a couple of times in a decade (Jacobs 2015a).

- Movement/Dispersal – movement of individuals throughout the river is linked to the food web function. By providing alternative flows different areas of the river are accessible for foraging by fish and other aquatic fauna. Flow and connectivity also facilitates dispersal of juveniles either to other areas within the Loddon River or the Mid-Murray floodplain system. Both Silver and Golden perch respond to high flow and movement into this between reaches 4 and 5 and Pyramid Creek is dependent on flow velocities. That is if Pyramid Creek has a greater flow than the flow in Reach 4 the fish are most likely to swim up Pyramid Creek and vice versa (O'Connor et al. 2013).

4.5 Conceptualisation of the site

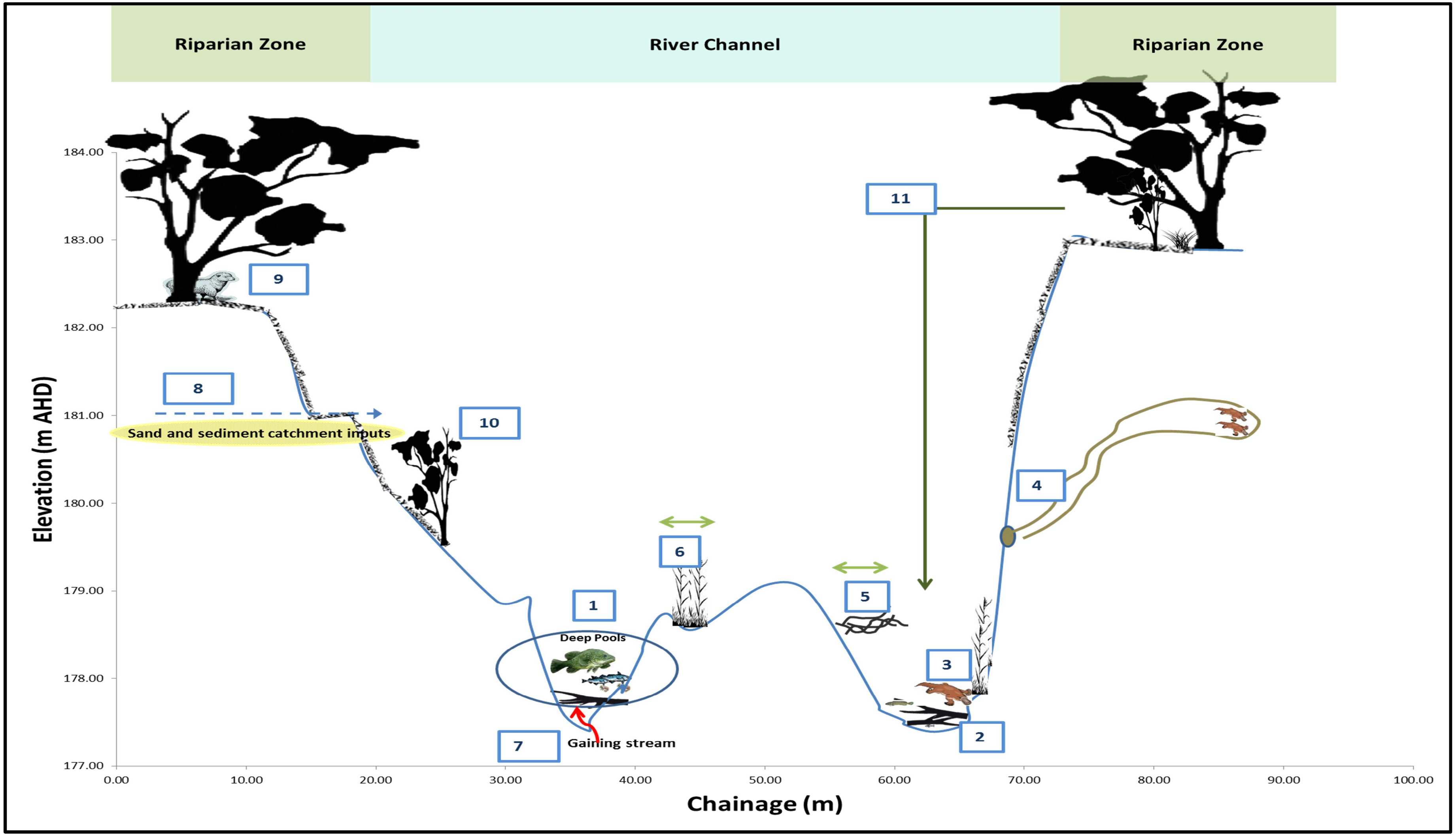

Figure 9: Cross section indicating conceptual understanding of deeper sections of the Loddon River System (predominantly the upper Loddon River)

Key:

1. Reach 2, 3a, 3b, 4a and 4d are characterised pool riffle/run habitat and contain a number of deep pools. These pools provide important habitat, particularly for large bodied fish and platypus. Are critical during periods of low to no flow for refuge.
2. Instream woody habitat is a critical habitat component providing shelter, biofilms, zooplankton, macroinvertebrates, fish and platypus larder
3. When lactating a female Platypus can eat up to 80% of her own bodyweight in macroinvertebrates
4. High flows in August are required to cue Platypus to establish breeding burrows higher on the bank if high flows have not occurred for some years
5. Instream vegetation provides shelter and food for macroinvertebrates, small fish and tadpoles which provide food for Platypus and Large bodied fish. As at 2015, instream vegetation exists in small stands predominantly in the upper Loddon River after the 2011 floods significantly removed instream flora from the channel. Summer low flow will support instream taxa, such as *Triglochin app.* Differing climate (dry, average, wet) and flows (low, fresh, bankfull) will cause stands to expand and contract within the wetted areas of the channel. Emergent vegetation exists in small stands in Reach 2 after 2011 floods significantly scoured extensive stands from the channel.
6. Freshes from late winter to early summer will encourage germination of a diversity of emergent species (such as *Bolboschoenus spp*. *Eleocharis* spp. or *Phragmites*). Emergent vegetation provides shelter for macroinvertebrates and frogs, small fish when inundated. Both instream and emergent vegetation are carbon sources
7. Reaches 1, 2 and part of 3a are gaining reaches (i.e. leakage from the groundwater table to the stream).
8. Sand and sediment inputs from adjacent land are sources of sand slugs and sedimentation of substrate
9. Riparian zone primarily comprises mixed age River Red Gum trees with very little evidence of recruitment and sparse understory where stock access is still prevalent.
10. Spring freshes promote Red Gum recruitment on benches.
11. Riparian vegetation is a source of carbon (e.g. leaf litter, insects) and instream woody habitat to the river

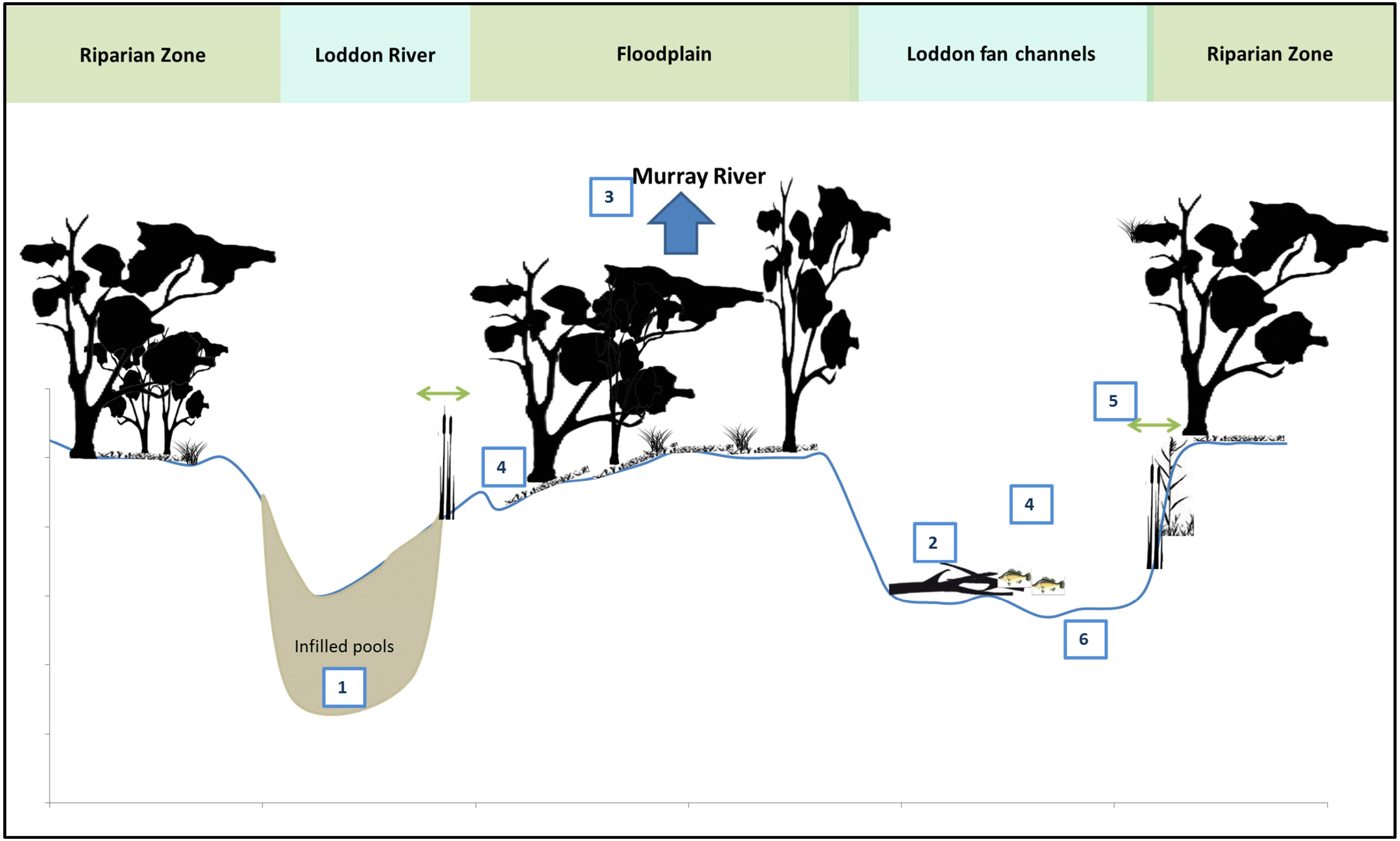

Figure 10: Conceptual understanding of the lower lying floodplain and the Loddon River fan (predominantly the mid-Loddon River)

Key:

1. Sedimentation of deep pools has reduced available refuge habitat for periods of low flow.

2. The early life stages of fish require nursery habitats, and for many fish these are slackwater areas (no or negligible flow). These provide sheltered, usually warm, food-rich areas conducive for survival and growth. Either the adults spawn there or larvae move there themselves (All reaches)

3. Fish passage on the Kerang Weir, and soon to be on the Chute and Box Creek Weir, has reinstated connectivity between reaches 4, 5, Pyramid Creek, Kow Swamp and the Murray River for aquatic fauna, specifically native fish.

4. Reach 4 features a low lying floodplain and a series of anastomosing channels that are inundated at low flows creating diversity of habitat available for aquatic fauna.

5. Sedimentation of channel substrate and pools provide suitable substrate for emergent vegetation such as Phragmites to colonise. Continuous low flows present a potential risk of encroachment of reeds into the main channel.

6. Reach 4 is a considered a groundwater neutral reach (neither gaining nor losing).

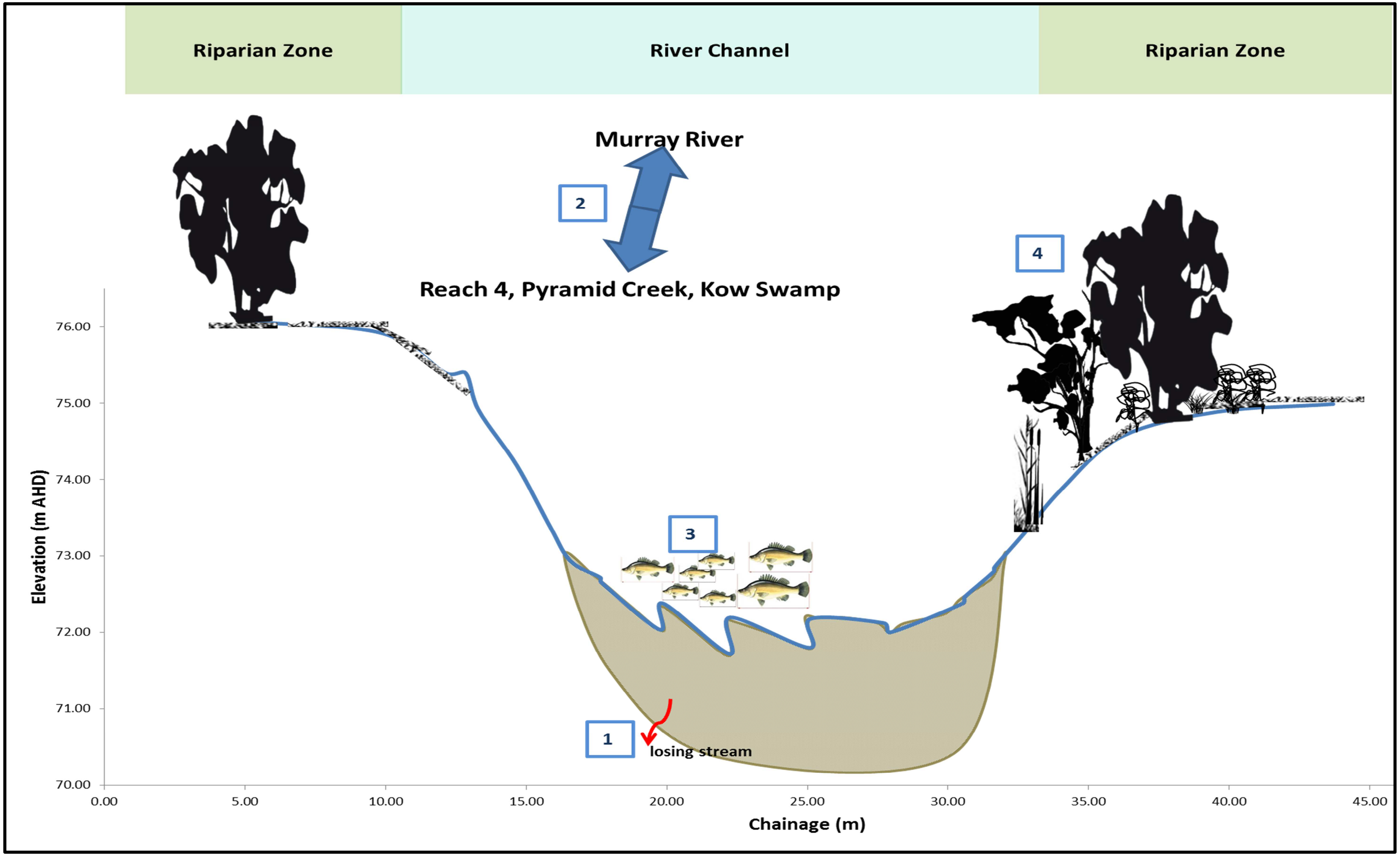

Figure 11: Conceptual understanding of the connectivity in the Loddon River System (the mid- and lower-Loddon River)

Key:

1. Reach 5 and Part of Reach 3 are losing streams
2. Reach 5 is connected to the Murray River downstream and Reach 4, Pyramid Creek, Kow Swamp (Gunbower Creek system) up stream.
3. This connectivity will enable the mid and the lower Loddon River System to provide a critical role in the recovery of native fish in the Murray-Darling Basin
4. The lower Loddon River System (including the lower third of the mid Loddon River System) is primarily dominated by Tangled Lignum and Black Box communities. River Red Gum trees are located on the water's edge and are suspected to be a result of the irrigation system.

4.6 Significance

The Loddon River System is highly significant as a tributary river to the Murray River. It provides important ecological and biodiversity linkages in a region and landscape that has been highly modified. Although many stream barriers are still present, the removal of instream barriers in the Lower Loddon through the provision of fish passage at Kerang Weir, the Chute and the Box Creek Regulator provide new opportunities for connectivity facilitating migration, movement and dispersal.

The Loddon River System has significant habitat values such as extensive and complex IWH, large deep pools, secondary channels and backwaters that form slackwater under low flows. IWH is a critical structural component for the river, supporting food webs and providing shelter for macroinvertebrates, native fish and other aquatic fauna. Deep pools provide important drought refuge during periods of low to no flow. Slackwater areas when engaged provide warm nutrient rich nursery habitat for many native fish species.

The Loddon River System supports, or has been known to support, fauna and flora of national, regional and local conservation significance, in particular EPBC-listed native fish such as the Murray Cod, Silver Perch and Macquarie Perch, and regionally significant species such as River Blackfish and Platypus.

The upper and mid Loddon features an almost continuous mixed age River Red Gum vegetation community, with wider vegetated floodplain in the low lying areas in the mid Loddon providing opportunities for lateral connectivity. Many native vegetation communities within the catchment are considered endangered or vulnerable.

5 Ecological condition and threats

5.1.1 Context

The current condition of the Loddon River System has been impacted by a long history of regulation exacerbated by the extreme weather events of the Millennium Drought and the 1 in 100 year floods that occurred in January 2011 (as discussed in Section 3). Cairn Curran and Tullaroop reservoirs nearly dried and coupled with low to zero seasonal determinations, the North Central CMA was unable to deliver most of the recommended environmental flows (Appendix 2). Significant lengths of the mid Loddon River dried, and the Tullaroop Creek was restricted to deep pools. The health of River Red Gums along much of the river declined and River Red Gum saplings and emergent plants such as Phragmites and Typha encroached into the river channel.

Rainfall conditions significantly improved in the 2010 winter/spring period resulting in natural high river flows. In January 2011 extensive flooding occurred in the Loddon River catchment providing extensive overbank flows. The 2011 flood scoured or drowned most of the established vegetation from the channel, as well as instream vegetation. River Red Gum recruitment occurred beyond the confined riparian zone (public land water frontage boundaries). In most areas that aligned with agricultural land the saplings have been removed (Jacobs 2015a).

The Loddon River is a 'working' river and its condition is reflective of its multiple uses, in particular, its role in harvesting, storing and delivering water for consumptive needs. Generally regulated management harvests natural inflows, usually during winter and spring, and releases higher flows over the warmer months of the year when evaporation exceeds precipitation. This type of managed flow regime characterised by seasonal inversion and lack of overbank floods, is inappropriate for many water dependent environmental values along the river (Jacobs 2015a).

Further, other threats such as instream barriers, historic commercial harvesting of fish in the Murray-Darling Basin, introduced flora and fauna, land clearing, livestock access and grazing of river banks, have all degraded the condition of the Loddon River (Humphries & Winemillar 2009; Jacobs 2015a; O'Brien et al. 2006; SKM 2014b).

5.1.2 Current condition

Previous condition assessments

The Sustainable Rivers Audit (SRA) was undertaken at a Murray-Darling Basin scale. The SRA provides scientifically robust assessments of the ecological health of the Basin's 23 river valleys, based on assessment of observations of fish, macroinvertebrates, vegetation, physical form and hydrology. These are then compared to the reference condition[6] for the Valley to derive the score. SRA 1 is based on data collected from 2004 – 2007 and assessed fish, macroinvertebrates and hydrology. SRA 2 is based on data collected from 2008 to 2010 and includes additional reports on physical form and vegetation. Direct comparison between values for the two SRA assessment reports are valid in some cases (Davis et al. 2012) however, changes in methodology and additional information collated needs to be considered. The Loddon Valley was divided into three zones, the upland, the slopes and the lowland. The Loddon River downstream of Cairn Curran and Tullaroop reservoirs includes the slopes and lowlands zones. Table 14 details the results of the two SRA reports. It should be noted that the MDBA has issued a caveat that SRA 2 results should be interpreted in the context that prevailing climate conditions for period in which the data were collected included the severe Millennium Drought. NB: Serpentine Creek, Twelve Mile Creek and Pyramid Creek were not included in the Sustainable Rivers Audit.

[6] Reference condition is an estimate of condition had there been no significant human intervention (i.e. pre European settlement) in the landscape, provides a benchmark for comparisons

Table 14: MDBA Sustainable River Audit indices ratings and trajectories for the Loddon River

Parameter	SRA 1		SRA 2	
Zone	**Slopes**	**Lowlands**	**Slopes**	**Lowlands**
Fish (SR-F1)	Extremely Poor	Very Poor	Extremely poor	Very poor
Macroinvertebrates (SR-MI)	Poor	Poor	Moderate	Moderate
Vegetation (SR-VI)	Not assessed		Extremely poor	Extremely poor
Physical Form (SR PI)	Not assessed		Moderate	Good
Hydrology	Moderate to Good	Very Poor to Moderate	Good	Moderate
Ecosystem Health Rating	Very Poor	Very Poor	Very poor	Very Poor
Source: Adapted from Davis et al. 2008; Davis et al. 2012.				

The Index of Stream Condition (ISC) is a state-wide assessment of river condition. ISC measures the relative health across hydrology, physical form, stream side zone, water quality and aquatic life against a reference condition[7]. Assessments were undertaken in 1999, 2004 and 2010 (DEPI 2013c). Due to the changes made to the methods for all five sub-indices, it is difficult to make direct comparisons using the sub-index scores. It should be noted that the ISC reaches are delineated differently to environmental flow reaches, ISC reach numbering starts at the Murray River while environmental flow reaches starts at Malmsbury Reservoir on the Coliban River. ISC Reaches 1 to 5 align with the Campaspe River downstream of Lake Eppalock. The results of the three assessments against the ISC reaches (aligned against FLOWS reaches) are shown in Table 15. NB: ISC was not undertaken for Twelve Mile and Pyramid Creeks.

Table 15: 1999, 2004 and 2010 Index of Stream Condition sub - indices scores and trajectories for the Campaspe River

ISC Reach No.	E-flow No.[1]	Physical Form			Stream-side zone			Hydrology			Water Quality			Aquatic Life			Total Score			Condition		
		99	04	10	99	04	10	99	04	10	99	04	10	99	04	10	99	04	10	99	04	10
1	R5	5	5	10	6	4	6	0	1	6	-	-	-	-	-	5	15	14	30	VP	P	M
2	R4d,R5	5	7	10	7	3	6	0	0	6	6	5	5	-	-	6	18	13	30	VP	P	M
3	R4d	5	4	10	5	5	6	0	0	6	-	-	-	8	-	6	18	11	32	VP	VP	M
4	R4a,R4d	4	5	9	4	5	7	0	0	6	-	-	-	9	-	6	15	13	33	VP	P	M
5	R4a	4	4	7	5	4	6	0	0	6	7+	8+	-	8+	-	4	18+	15	27	VP	P	M
6	R3a,R3b	5	4	7	5	5	6	0	1	6	6	8	8	8	-	6	18	18	31	VP	M	M
7	R3a	5	5	8	6	5	6	0	0	6	6	6	6	4	5	8	16	17	32	VP	P	M
8	R1	5	2	6	6	4	6	0	2	6	-	-	-	-	-	8	15	12	31	VP	VP	M
11	Serp	6	4	7	5	4	6	0	6	0	-	-	-	8	-	6	18	22	19	VP	M	VP
18	R2	4	3	5	4	4	5	5	2	6	-	-	2	-	9	9	23	17	22	P	P	P

KEY:
VP- very poor; P- poor; Ma- marginal; M- moderate; G- Good
[1]indicative environmental flows reach number R1-Reach1, R2-Reach2, R3a-Reach3a, R4a–Reach 4a, R4c-Reach 4c, R4d-Reach 4d; R5-Reach 5; Serp – Serpentine Creek

Source: adapted from DSE 1999, DSE 2004b; DEPI 2013c

Vegetation

The Vegetation SRA (Slopes and Lowlands) score from the Millennium Drought and the ten ISC Streamside Zone Scores indicate that vegetation in the Loddon River System has been in poor condition , albeit slightly improving from 2004 to 2010 under ISC (DEPI 2013c). This slight improvement in ISC scores for streamside zone cannot be confidently interpreted as an improvement in condition, because the method and sampling protocol changed from 2004 to 2010.

Both vegetation assessments relate to the width and continuity of the riparian zone, which is restricted by and large by land tenure and the score is a reflection of the fact that sections of the Loddon River riparian zone is largely restricted to within the channel (SKM 2013). The VEFMAP 2013 vegetation surveys found the majority of the riparian zone comprises mixed age class River Red Gum trees with the understory was sparse and dominated by exotics along the upper and mid Loddon River with Black Box and dense Lignum dominating the lower Loddon River (SKM 2014b). Observations during the field trip by the EFTP on 2 and 3 February 2015 confirmed that this was still the case, however where fencing has occurred evidence of recruitment of native understorey and canopy species is evident (Jacobs 2015a). Sections of the riparian zone along Reach 4, where the overbank flow occurs at low flows, have wider riparian buffers. This is possibly indicative of the likelihood

[7] Reference condition has the same definition as the SRA.

of flooding. River Red Gum recruitment that occurred in response to the January 2011 flood was observed higher on the banks along Crown land or where landholders had fenced larger areas.

The Environmental Flows Assessment for the Lower Loddon (SKM 2010) designed its objectives and flow recommendations to halt and attempt to reverse the encroachment of River Red Gum saplings and emergent plants such as Phragmites and Typha into the river channel, which had occurred due to years of low flow conditions during the drought. The flooding of January 2011 removed drowned the saplings and either drowned or scoured the reed beds and in the 2013 VEFMAP survey there was little evidence of instream vegetation throughout the river channel (SKM 2014b). Both instream and emergent vegetation has started to recover throughout the river, with a higher diversity of emergent species (such as *Bolboschoenus* spp., *Juncus* spp. and *Carex* spp.) observed where fencing has occurred compared to littoral vegetation dominated by Common Reed areas where livestock access was observed (Jacobs 2015a).

Fish

The SRA score for native fish was “extremely poor” in both audits for the Slopes and very poor for Lowlands. The score is low because a number of species expected to be present were not recorded during either audit. Native species contributed to just over 60% of abundance but only than 21% of the biomass. The majority of the biomass was Common Carp (*Cyprinus carpio*) (Davies et al. 2012). Common Carp is a generalist species, persisting under a wide range of conditions and exploiting a wide range of food sources (Weber & Brown 2009).

VEFMAP monitoring supports the SRA fish assessment. Figure 12 shows that the biomass in each reach is dominated by exotic fish, particularly Common Carp. Very low numbers of large bodied fish, such as Murray Cod and Golden Perch have been captured (despite Murray Cod and Golden Perch being stocked) in all reaches and a few single records of Silver Perch (not stocked) exist in reach 3b and 4 (Jacobs 2014f).

Historically large bodied fish are likely to have been represented in far greater numbers and contributed to a much greater proportion of the biomass (Davies et al. 2008; Davis et al. 2012; Humphries & Winemiller 2009). Further, Murray-Darling Basin species that would have historically been present and abundant are presumed lost from the river (Davies et al. 2008; Davis et al. 2012; Jacobs 2014f). Table 16 shows the native fish species expected to be present and relevant abundance in a reference condition lowland inland river (Davis et al. 2008; Davis et al. 2012).

Table 16: Pre-1750 fish species and their rarity

Common Name	Scientific Name
Common	
Australian Smelt	*Retropinna semoni*
Flathead Gudgeon	*Philypnodon grandiceps*
Golden Perch	*Macquaria ambigua ambigua*
Gudgeon	*Hypseleotris spp*
Murray Cod	*Maccullochella peelii*
Moderate	
Bony Herring	*Nematalosa erebi*
Freshwater Catfish	*Tandanus tandanus*
Macquarie Perch	*Macquaria australasica*
Murray Jollytail	*Galaxias rostratus*
Murray-Darling Rainbowfish	*Melanotaenia fluviatilis*
Obscure Galaxias	*Galaxias sp1*
River Blackfish	*Gadopsis marmoratus*
Silver Perch	*Bidyanus bidyanus*
Southern Purple-spotted Gudgeon	*Mogurnda adspersa*
Trout Cod	*Maccullochella macquariensis*
Unspecked Hardyhead	*Craterocephalus stercusmuscarum fulvus*
Uncommon	
Congolli	*Pseudaphritis urvillei*
Dwarf Flathead Gudgeon	*Philypnodon sp1*
Murray Hardyhead	*Craterocephalus fluviatilis*
Shorthead Lamprey	*Mordacia mordax*
Southern Pygmy Perch	*Nannoperca australis*
Key: 5= common, 3= moderate, 1= uncommon, **Source:** Davis et al. 2008; Davis et al. 2012.	

Macroinvertebrates

Both SRA and ISC scores for macro invertebrates are based on presence/absence of tolerant vs intolerant taxa. Presence of rare families in the Slopes represented taxa associated with cool flowing water (Davis et al. 2008; Davis et al. 2012; DEPI 2013c). The upper Loddon River is likely to support macroinvertebrate communities that are more suited to faster flowing streams, however the entire macroinvertebrate community in the Loddon River System is dominated by species that can tolerate relatively poor water quality and is typical of many lowland rivers in Northern Victoria (Jacobs 2015a). The macroinvertebrate communities in the Loddon River System have been heavily impacted by land-use changes such as mining activities in the upper catchment, clearing of the riparian zone and unrestricted stock access that have collectively delivered high sediment loads to the river, which have filled pools and smothered other potential macroinvertebrate habitats (Jacobs 2015a).

Despite the dominance of tolerant taxa indicating poorer water quality from reference condition, the majority of the functional groups are present. These functional groups are integral to the food web of the Loddon River System. They play a significant role in breaking down coarse particulate organic material, nutrient cycling and other ecological processes and a diversity of taxa are an important food source for native fish, Platypus and other aquatic biota (Jacobs 2015a).

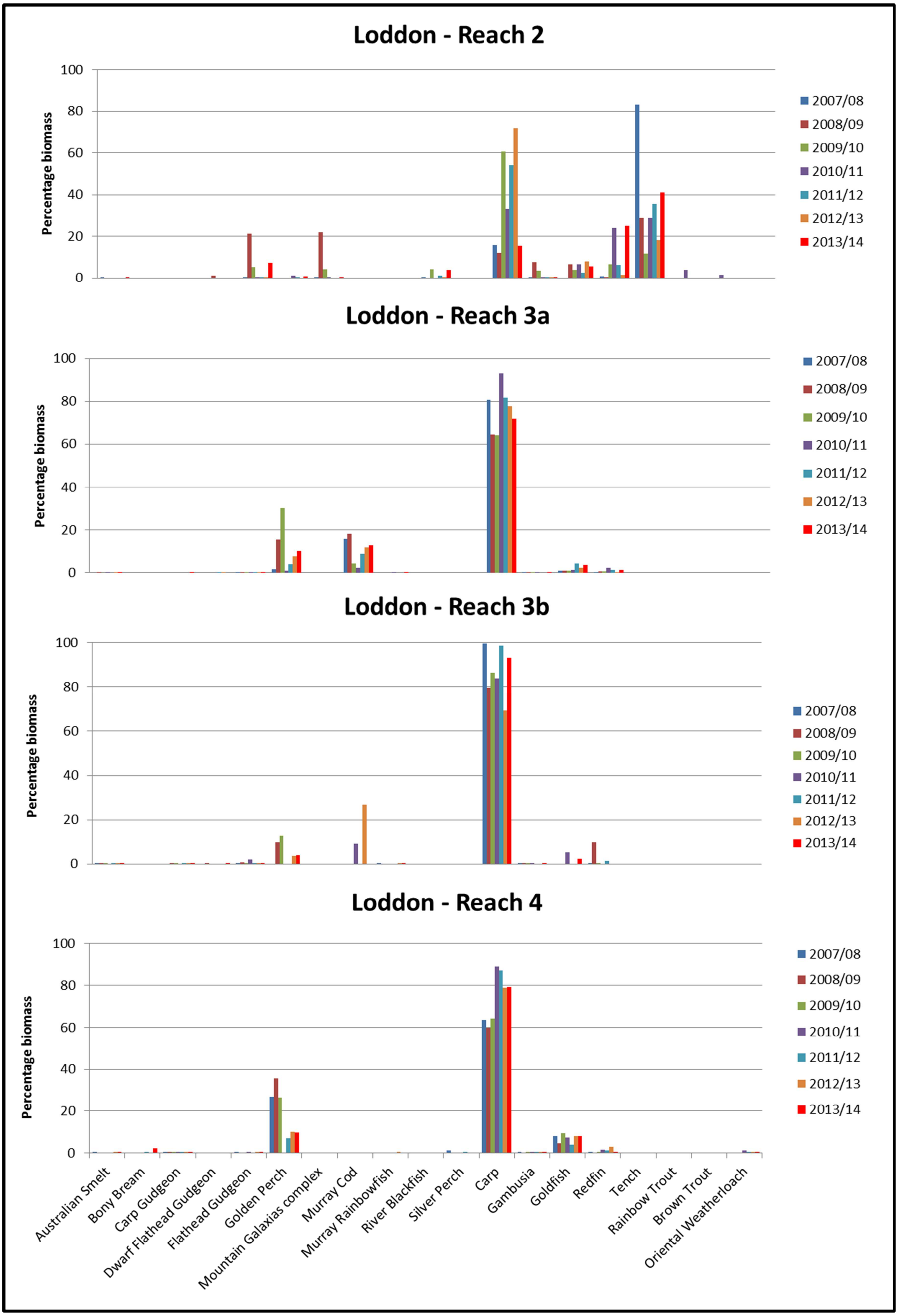

Figure 12: Biomass of native fish vs exotic fish as captured in VEFMAP fish surveys (Jacobs 2014f).

5.1.3 Current trajectory – do nothing

Without environmental water, the Loddon River System will continue to be operated to deliver water from the Loddon, Goulburn and Murray systems for consumptive needs. Further GMW is proposing to connect a significant number of irrigators directly to the Loddon River in Reach 5 and Pyramid Creek. Primarily operation of the river purely for consumptive purposes will result in harvesting of winter and spring inflows and release of water during peak irrigation period (when evapotranspiration exceeds precipitation). This also needs to be considered in light of climate change predictions that under a best estimate scenario by 2030 there will be a 16% reduction in average annual runoff in the catchment, an 18% reduction in average surface water availability and a 27% reduction in end of system flows (CSIRO 2008). If the regulated river is operated for consumptive water needs only, and allocations are significantly reduced under climate change scenarios the following ecological consequences could occur (Jacobs 2015a; LREFSP 2002a; SKM 2010b;):

- Loss of aquatic in-stream vegetation such as include Ribbonweed, Eel Grass, Water Ribbons, and pondweeds
- Retraction of the extent, and possibly also floristic diversity, of emergent non-woody macrophytes such as rushes and reeds, twig-rushes, club-rushes and club-sedges, sedges, and spike-rushes
- Limited recruitment of River Red Gum in the riparian zone nearest the stream
- Decrease in the condition of adult River Red Gum
- Loss of macroinvertebrates biomass and plant functional groups
- Unsuccessful recruitment of native fish flushing out of slackwater habitat by discharges of irrigation water at high flow rates through the summer for small bodied fish (e.g. Murray-Darling Rainbowfish) and Lack of high flows to cue spawning for large bodied fish (e.g. Murray Cod)
- Loss of medium to large-bodied fish in reaches without deep pool habitat due to lack of flow
- Potential loss of Platypus population as was experienced in the Wimmera system during the Millennium Drought.

6 Management objectives

6.1 Management goal

The long term management goal for the Loddon River System has been derived from a variety of sources including technical reports, the VWMS and North Central Waterway Strategy goals. It incorporates the environmental values identified in Section 4 and seeks to address the condition and condition trajectory discussed in Section 5.

> **Loddon River system long term management goal**
>
> Promote a widespread and diverse aquatic fauna community particularly native fish and Platypus, by providing high quality breeding and feeding habitat and where possible facilitating movement throughout the Mid-Murray Floodplain System. Rehabilitate riparian River Red Gum vegetation communities along the river, and where possible connect floodplain habitats, through the provision of an appropriate flow regime.

6.2 Ecological objectives

For the Loddon River the ecological objectives established in the previous flows studies have been reviewed and refined based on values proposed by community consultation and new information such as VEFMAP monitoring data. Ecological objectives for Serpentine and Pyramid creeks were established in flows assessments undertaken in 2015 (Jacobs 2014d; Jacobs 2014e). The review recognised that while some of the objectives differed slightly between reaches, they are generally consistent across the whole river system.

Ecological objectives are presented as primary objectives, with sub-objectives and secondary objectives. These have been collaboratively established by the North Central CMA and EFTP. Primary objectives are related to the key values of the Loddon River System and summarise the overall objectives for those values. The sub-objectives provide greater detail for achieving the primary objective. Secondary objectives either support the primary objectives (e.g. macroinvertebrates are a food source for fish and Platypus) or are objectives for values for which little baseline information is known (e.g. freshwater turtles). If the monitoring budget in future years is restricted it is anticipated that the North Central CMA will prioritise monitoring of primary objectives.

The ecological objectives shown in Table 17 are to be achieved through the provision of environmental water over the next ten years.

Table 17: Ecological objectives for the Loddon River System (Jacobs 2014a: Jacobs 2014g; Jacobs 2015a)

Objective		Justification	Reach
Primary objectives			
Fish			
PF1	To increase the population size, with an appropriate age structure, of native fish species in the impounded Loddon River System reaches	See sub-objectives	Upper Loddon, Serpentine Creek
PF1.1	Increase population size (with appropriate age structure) and distribution of River Blackfish and facilitate re-colonisation of Reach 1 via Laanecoorie Reservoir.	River Blackfish would have been moderately common and abundant in the Loddon River, but are now restricted to a small, potentially fragmented populations in Tullaroop and Serpentine creeks.	Reach 2 and Serpentine Creek reaches S1, S3
PF1.2	Enhance natural recruitment and dispersal of stocked Murray Cod populations in disconnected impoundments e.g. Laanecoorie Reservoir, Serpentine Weir pool, Loddon Weir pool, and large pools between Laanecoorie Reservoir and Serpentine Creek (Durham Ox weir pool).	Murray Cod is stocked in Laanecoorie Reservoir, Serpentine Weir, Loddon Weir, several large pools in Reach 3a and Serpentine Creek. Artificial barriers prevent Murray Cod moving into the Upper Loddon River from downstream reaches, but high flows at the right time could trigger spawning and recruitment in existing stocked populations. Individual fish may move into the main river channel during higher flow events and then retreat to the Reservoir as water levels drop.	Reaches 1, 2, 3a and 3b, Serpentine Creek Reach S3

Objective		Justification	Reach
PF1.3	Maintain habitat for stocked populations of Golden Perch in disconnected reaches e.g. Laanecoorie Reservoir, Serpentine Weir pool, Loddon Weir pool, and large pools between Laanecoorie Reservoir and Serpentine Creek	Golden Perch is stocked in Cairn Curran Reservoir, Laanecoorie Reservoir, Serpentine Weir, deep pools within Reach 3a and Serpentine Creek. They are unlikely to successfully breed in this reach, but habitat could be provided to allow them to move throughout individual reaches during high flows.	Reaches 1, 2, 3a and 3b, Serpentine Creek Reach S3
PF1.4	Increase population size (with appropriate age structure) of small-bodied native fish species including Murray-Darling Rainbowfish, Flathead Gudgeon, Carp Gudgeon, and Australian Smelt.	These species would have naturally been abundant throughout the river, but their abundance has declined likely as a result of habitat degradation, river regulation and drought.	Upper Loddon, Serpentine Creek
PF2	To increase the population size, with an appropriate age structure, and the diversity of native fish species, in the connected mid and lower Loddon River System	See sub-objectives	Reach 4, Reach 5 and Pyramid Creek
PF2.1	Increase population size and diversity (with appropriate age structure) of small-bodied native fish species including Murray-Darling Rainbowfish, Flathead Gudgeon, Carp Gudgeon, and Australian Smelt.	These species would have naturally been abundant throughout the river, but their abundance has declined likely as a result of habitat degradation, river regulation and drought.	Reach 4, Reach 5 and Pyramid Creek
PF2.2	Enhance natural recruitment of Murray Cod population and allow fish to disperse and colonise suitable habitats in the Mid-Murray floodplain system.	The main objective for Murray Cod and other large bodied species with an equilibrium life history strategy is to provide habitat upstream and downstream of Canary Island and in the Lower Loddon River that will allow existing fish to survive during low flow periods, to provide flows that will support successful breeding in those areas and to provide conditions that will allow fish to regularly move throughout all reaches and to move between the Middle Loddon River, Lower Loddon River, Pyramid Creek, Gunbower Creek and the Murray River.	Reaches 4a, 4d and 5, Pyramid Creek.
PF2.3	Extend available critical habitat to facilitate recolonisation of large bodied fish such as Silver Perch and Golden Perch populations in the Mid-Murray floodplain system	Both perch species were common in the Loddon River, but were lost from the Middle Loddon River during the Millennium Drought. Recent fish monitoring confirms that these species have returned to the Middle and are present in the Lower Loddon River. Golden Perch and Silver Perch are periodic spawners that move long distances to spawn in response to high flow events. Therefore it is not expected that these species will have high rates of spawning and successful recruitment in the Loddon River, therefore the main objective will be to provide flows and habitat for feeding in the Middle Loddon River from the Lower Loddon River, Murray River and Pyramid Creek. It will be important to provide permanent habitat with moderately deep pools and woody debris and abundant food in the reaches upstream and downstream of Canary Island and in the Lower Loddon River; and provide suitable conditions to allow fish passage through Twelve Mile Creek and the West Branch of the Loddon River in winter and spring.	Maintain permanent habitat and opportunities for movement in Reaches 4a, 4d, 5 and Pyramid Creek.

Objective		Justification	Reach
Platypus			
PP1	Increase size of resident breeding Platypus populations and facilitate dispersal of surplus juveniles that can colonise other reaches of the Loddon River and connected catchments.	The upper reaches of the Loddon River and the Loddon River near Kerang would have naturally supported permanent breeding populations and provided juveniles platypus that could colonise other areas such as the Murray River between the Goulburn River and Swan Hill and Gunbower Forest. The Platypus populations in the Loddon River are currently fragmented. The upper Loddon River supports resident breeding populations, but they are likely to have declined significantly during the drought. Platypus numbers have also declined in the Kerang Weir pool. Much of the middle Loddon River is unsuitable for Platypus breeding populations because the banks are not very high and there are limited deep pools, but those reaches are important dispersal corridors. This objective should be achieved by facilitating successful recruitment at least every second year and promoting safe dispersal by juveniles in autumn or early winter.	Reaches 1, 2, 3a, 3b and 5 Serpentine Creek Reach S1, S3
Vegetation			
PV1	Maintain adult riparian woody vegetation (e.g. River Red Gum, Black Box, Bottlebrush, Tea Tree, *Melaleuca* and Tangled Lignum – species composition will vary between reaches) and facilitate recruitment adjacent to the river channel and in low lying floodplain areas that are watered via floodrunners	The riparian zone in most reaches of the Loddon River is relatively narrow and in places is comprised almost exclusively of adult River Red Gum with a pasture grass understorey. There is little evidence of recent recruitment in most reaches, although the 2011 floods triggered successful recruitment in sections of the Middle Loddon River where stock have been excluded. An appropriate flow regime combined with complementary actions to exclude stock may allow new River Red Gum recruitment and establish a diverse shrub layer, which will help stabilise banks and reduce future erosion.	All reaches
PV2	Maintain low lying floodplain vegetation communities. These communities are characterised by a River Red Gum overstory and grassy, sedge or lignum understorey.	The capacity of the main river channel decreases markedly through the Middle Loddon River. Flood runners carry water from the channel to nearby woodlands and wetlands and some such as those in the lower half of Twelve Mile Creek support their own wetland vegetation communities. These flood runners need to be engaged by moderate to high flows every few years to maintain distinct vegetation communities on the floodplain.	Lower portion of Reach 4a, all of Reach 4b and all of Reach 4c.
Secondary Objectives			
Vegetation			
SV1	Maintain and increase spatial extent of in-stream vegetation	Instream vegetation is generally poor at sites that have mobile streambed substrates and uncontrolled stock access. Large pools in Upper Loddon River have particularly good patches of submerged vegetation, but mid and lower Loddon River is more turbid and therefore will expect greater abundance of floating species such as *Triglochin* and *Myriophyllum.*	All reaches
SV2	Increase diversity and appropriate spatial extent of native emergent fringing non-woody vegetation along the banks and in floodrunners or anabranches.	The current fringing vegetation community is dominated by *Phragmites*, which was extensive during drought, but cleared out by the 2011 floods. Stands of other species such as *Bolboschoenus*, *Carex* and *Juncus* persist in some areas Aim to extend the longitudinal extent of these.	All reaches

Objective		Justification	Reach
SV3	Maintain biofilm productivity, especially on coarse woody debris.	Biofilms that grow on submerged wood and other hard surfaces are an important part of aquatic ecosystems. They are particularly important in the Middle and Lower Loddon River because the turbid water is likely to limit the growth of instream vegetation and there is a large load of submerged wood on which biofilms can grow. Periodic wetting and drying is important for re-setting biofilms and increasing their productivity. Water levels should vary during low flow periods to facilitate these wetting and drying patterns and to increase the range of substrates that are inundated in the photic zone.	All reaches
Other Aquatic Biota			
SB1	Maintain/Increase aquatic biota such as Freshwater turtles, native frogs and water rats	Freshwater turtles, frogs and water rats have been observed throughout the Loddon River System, however current status of these species is unknown	All reaches
SM1	Maintain/increase diversity and productivity of macroinvertebrates and macroinvertebrate functional feeding groups to drive productive and dynamic foodwebs.	Macroinvertebrate community productivity and diversity of functional groups is likely to be determined by range of available habitat types. It will be good at sites with a mix of instream and emergent vegetation, submerged wood and a supply of leaf litter from the riparian zone, but poor at sites that are missing one or more of these habitat elements.	All reaches
Water Quality			
SWQ1	Maintain water quality at a level that is able to support fish and macroinvertebrates. In particular maintain adequate concentrations of dissolved oxygen, prevent salinity levels rising above 3,000 EC and prevent excessive water temperatures during low flow periods.	During critically low flow periods dissolved oxygen concentrations in remnant pools can be depleted, salt concentrations due to groundwater inflows may rise and water temperature may become too warm for some sensitive fish and macroinvertebrate species. High salinity a particular risk in groundwater gaining reaches including Tullaroop Creek, Loddon River between Cairn Curran Reservoir and Bridgewater and Loddon River immediately downstream of Loddon Weir.	All reaches
Geomorphology			
SG1	Re-establish deep pools in areas that have been affected by sand slugs, maintain existing pools in other areas and replenish benches within the channel.	Channel form and habitat heterogeneity are critical to providing habitat and food for aquatic and riparian flora and fauna. In particular deep pools provide a critical drought (and potentially flood) refuge for aquatic fauna and flora. Many pools in Tullaroop Creek, and the Middle and Lower Loddon River have filled or partially filled with sediment. Large flows in the Upper Loddon River may generate enough shear stress to scour pools, but lower gradients in the Middle and Lower Loddon River mean large flows are more likely to maintain existing pools rather than create new large pools.	All reaches, but especially in Tullaroop Creek (Reach 2) where sand slugs have filled a large proportion of channel pools.
SG2	Flush accumulated silt and sediment from substrates including rocks, submerged wood and macrophytes	Regular flows that flush silt and fine sediment from hard surfaces will increase their suitability for macroinvertebrates and biofilm production and lead to an overall increase in biological productivity and diversity.	All reaches

6.4 Flow Recommendations

Flow recommendations describe the components of a flow regime required to achieve the ecological objectives. All values identified have parts of their life-cycle or process that are dependent on particular flow components for success e.g. native fish require certain timing, duration and frequency of flooding to successfully breed and maintain their population. Flow recommendations have been set considering the following factors:

- the preferred timing of watering events
- the recommended duration for watering events
- the tolerable intervals between events (condition tolerances)
- the volume required to provide these events – per event / per season.

6.4.1 Description of flow components

Flow components for the Loddon River System are described as two seasons (summer and winter) as per the FLOWS method (DEPI 2013d). The summer season, from December to May, also encompasses autumn and the winter season, from June to November, also encompasses spring. This roughly aligns with the natural shift from wetter weather and greater inflows in winter and spring, and drier weather with greater evaporation and less inflows in summer and autumn.

6.4.1.1 Cease to flow

A cease-to-flow event is when the river stops flowing and aquatic habitat is restricted to pools. Cease-to-flow events, based on anecdotal evidence and hydrological modelling, are likely to have naturally occurred in the Loddon River System. However, prior to regulation, the Loddon River had extensive deep pool habitats, and native aquatic biota populations were much more abundant and therefore resilient to the stresses of a cease-to-flow event, such as reduced habitat availability and decline in water quality. Due to the degradation of the geomorphology (e.g. siltation of deep pool habitat) and the current condition of the native biota (e.g. low abundance and diversity of native aquatic species), a cease-to-flow event is not recommended in any of the reaches in the Loddon River System (Jacobs 2015a; Jacobs 2014a; Jacobs 2014g).

If a cease-to-flow event is unavoidable due to reduced water availability, then sufficient environmental water should be held in storage to deliver up to three summer freshes (see 6.4.1.3) to prevent extremely low dissolved oxygen concentration or high electrical conductivity levels in refuge pools (Jacobs 2015a), and to flush accumulated organic debris from the river bed to reduce the risk of water quality issues, such as hypoxic blackwater events and acidification, when flows return to the system.

6.4.1.2 Summer low flow

A summer low flow provides a continuous flow throughout the channel of the river connecting deep pool habitats, transporting nutrients and carbon and allowing movement of aquatic fauna (DSEWPaC 2013; Jacobs 2015a; Jacobs 2014a; Jacobs 2014g). In average to wet years the summer low flow should ensure a minimum depth of 10cm in the channel thalweg in riffle or run habitats and wet more than 70% of the bottom width of the channel and provide a depth of greater than 80 cm in pools. In dry years the summer low flow will provide a depth of at least 7 cm in the channel thalweg in riffle and run habitats and will only wet approximately 50% of the channel width (Jacobs 2015a).

The aquatic ecosystem is most productive under these flow conditions, with higher rates of nutrient and carbon cycling due to warmer temperatures. Low turbidity levels and slower flow rates allow photosynthesis by aquatic plants and attached algae within the river channel, which produces bioavailable organic carbon to support food webs (DSEWPaC 2013).

Summer low flow by maintaining slackwater habitats provides critical spawning and nursery habitat for native fish, particularly small to medium bodied fish, (Jacobs 2015a; Jacobs 2014a; Jacobs 2014g). Macroinvertebrates access riffle, pool and edge habitats during summer low flow, increasing biomass available for higher order consumers such as fish and Platypus.

In reaches 4 and 5 and in Pyramid Creek the summer low flow recommendations are higher than would have occurred naturally. In Reach 4 this is to reflect the lack of deep pool habitat in reaches 4b and 4c due to significant siltation, and the requirement to provide connectivity between reaches 4a and 4d for native fish (Jacobs 2015a). In Pyramid Creek is based on the minimum flow required to operate the Box Creek fish lock (both upstream and downstream fish passage), and is reflective of its use as an irrigation carrier. The flow objectives in Pyramid Creek is predominantly to reduce rapid fluctuations in level (Jacobs 2014g). The summer low flow recommendation for Reach 5 ranges between the minimum flow required to operate the Kerang fishway, and the maximum flow range that would pose minimal threat to slackwater habitat (Jacobs 2015a).

6.4.1.3 Summer fresh

Summer freshes are short duration increases in flow that will increase water depth by at least 10-20 cm compared to the summer low flow to inundate low benches, bars and fallen wood throughout the reach. It will also generate a shear stress of at least 1 N/m2 in moderate to fast flowing sections of the channel to flush fine silt and sediment form submerged wood and other hard surfaces. Summer freshes improves water quality by diluting salinity and re-oxygenating water in deep pools and transporting nutrients and carbon downstream reducing the risk of excessive plant growth (DSEWPaC 2013). Summer freshes wash fine silt and old biofilms off substrate (such as gravel and submerged wood) which in turn increases macroinvertebrate productivity (Jacobs 2015a; Jacobs 2014a; Jacobs 2014g). By wetting up the soil profile on the lower banks and benches, summer freshes promote the establishment, growth and survival of fringing emergent macrophytes such as reeds and sedges. Large adult fish and Platypus can access a diversity of habitat types and move between deep pools. Freshes also facilitate the dispersal of juvenile fish and Platypus, particularly in autumn.

Under managed conditions there is a potential conflict between delivering freshes to grow and maintain littoral vegetation and replenish biofilms on submerged wood and the risk that these events may disturb slackwater habitats and any fish larvae or juveniles in those habitats, particularly between November to February. Opportunistic species are likely to have multiple cohorts each season, so one fresh during that time should not significantly affect overall recruitment. Jacobs 2015a has emphasised the need for 3 events each year over the next 5-10 years to help re-establish fringing vegetation that was removed during the 2010/11 floods. Once those plants are established, the number of freshes may be revised.

6.4.1.4 Winter low flow

A winter low flow will increase water depth by at least 10-20 cm compared to the summer low flow and therefore maintain important seasonal variation. It will also wet the full width of the bottom of the river channel and generate enough shear force to flush fine sediment from the streambed and hard substrates in the fastest flowing sections of the stream (Jacobs 2015a; Jacobs 2014a; Jacobs 2014g).

A winter low flow inundates a range of habitats (low benches, banks and some secondary channels), supporting high macroinvertebrate productivity. A winter low flow facilitates localised movement throughout the reach and between connected reaches providing a range of foraging habitats for native fish and Platypus to develop fat reserves for spring spawning/breeding. Juvenile fish have access to shallow habitat on benches and edges, where they can hide from predators (such as larger fish). Winter low flows also facilitate long distance movement by juvenile male Platypus leaving their mother's territory and colonising elsewhere in the Loddon, Murray or Gunbower Systems (Jacobs 2015a; Jacobs 2014a; Jacobs 2014g).

A winter low flow should limit growth of vegetation in the middle of the channel, maintain open water in the thalweg throughout the whole reach and prevent terrestrial plants colonising the lower sections of the river bank and low benches in the channel. It will also maintain soil water in the river bank to water established River Red Gum and woody shrubs such as *Callistemon* and *Melaleuca*; and help sustain littoral vegetation that includes a mosaic of species such as *Bolboschoenus*, *Carex* and *Juncus* (Jacobs 2015a; Jacobs 2014a; Jacobs 2014g).

6.4.1.5 Winter fresh

A winter fresh will increase water depth by approximately 0.5-1.0 m above the winter low flow level and is sufficient to inundate low benches and backwater habitats throughout all reaches. It will also create a shear stress of 0.16-1.2 N/m2 in pool habitats and 3-5.3 N/m2 in riffle and run habitats. These shear stresses are sufficient to redistribute fine sediment on benches and bars in the bottom of the channel. A winter fresh will scour aged biofilms from hard surfaces including submerged wood, and flush accumulated leaf litter from bank and low benches into the river channel which in turn drives an increase in macroinvertebrate productivity (Jacobs 2015a; Jacobs 2014a; Jacobs 2014g).

A winter fresh event in September/ October (spring) should cue Murray Cod to spawn and allow Murray Cod, Golden Perch and other fish to move throughout each reach and between connected reaches (Jacobs 2015a).

Winter fresh events in September-October will promote recruitment and maintenance of riparian vegetation including Calistemon and other woody shrubs on low benches and on the river banks. The event will wet up the soil profile and water River Red Gum and other trees growing higher up the bank. Flows of this magnitude at any time will restrict the establishment of macrophytes in the bed of the river and maintain an open water flow path (Jacobs 2015a; Jacobs 2014a; Jacobs 2014g)

If a winter fresh has not been delivered for a number of years it is important to deliver a short duration flow in August to trigger female Platypus to establish breeding burrows higher up the bank to prevent drowning or starvation of juvenile Platypus (Jacobs 2015a; Jacobs 2014a).

6.4.1.6 Winter high flow

A winter high flow will increase water depth by 1-1.6 m compared to the winter low flow. It is specifically recommended to provide flow through anabranch channels, redistribute sediment on benches and bars in the bottom of the channel. A winter high flow will also establish and maintain woody and non woody vegetation on the river bank, on islands in the channel and in anabranch channels. The winter high flow will also perform the same functions as the winter fresh (Jacobs 2015a).

6.4.1.7 Bankfull flow

Bankfull flow events create the maximum shear stress within the river channel and hence determine the distribution and size of pools and benches throughout the reach. The bankfull flows will scour sediment from pools to maintain their volume and depth and replenish benches and bars within the channel (Jacobs 2015a).

Bankfull flows will help to maintain established trees such as River Red Gum high on the bank and support recruitment of juveniles. Ideally events will happen in consecutive years to help juveniles that recruit in the first year become established (Jacobs 2015a).

6.4.2 Environmental flow recommendations

The flow recommendations are presented for the upper, mid and lower Loddon River. Where values require particular timing for water this has been identified.

Table 18: Flow recommendations for the upper Loddon River System (Reaches 1,2,3a and 3b)

Flow component	Reach 1	Reach 2	Reach 3a	Reach 3b	Duration	Frequency and timing	Condition tolerances	Ecological objectives
Cease-to-flow	NA	NA	NA	NA	NA	Not recommended		Likely to be detrimental to water quality, prevent re-colonisation by instream vegetation, limit macroinvertebrate productivity and therefore limit fish and platypus populations.
Summer low flow (Wet/ average years)	20-35 ML/day	10-15 ML/day	25-35 ML/day (20-35 ML/day)	10-15 ML/day	6 months Dec-May	Vary the magnitude of flow within the prescribed range throughout Dec-May. Higher magnitude in Dec, gradual decline through Jan-Mar then gradual rise from Apr-May	The dry year recommendation can be delivered for most of the season in dry years as long as there is noticeable surface flow throughout the whole reach.	PF1.1, PF1.3, PF1.4 SV1, SV2, SV3, SV4. PP1 SB1. SM1. SWQ1.
Summer low flow (Dry years)	10 ML/day	5 ML/day	15 ML/day	5 ML/day				
Summer fresh (Wet/ average years) Summer Fresh (Dry years)	50-80 ML/day	40 ML/day	70-100 ML/day (50-100 ML/day)	50-60 ML/day	1-3 days at peak. Ramp up over 1-2 days and ramp down over 3-4 days.	3 events per year 1 event Dec-Feb with peak at 1 day 2 events Mar-May with peak at 2-3 days	No more than one fresh should be actively delivered in Dec-Feb to avoid disturbing slackwaters and River Blackfish nursery habitats during the main fish larval rearing phase. This recommendation may be ignored if water quality deteriorates in dry years and multiple freshes are needed to improve water quality in refuge habitats. More frequent events are OK after February in any year and may help facilitate Platypus dispersal.	PF1 SV1, SV2, SV3, SV4. PP1 SG2 SB1, SM1. SWQ1.
	35 ML/day	30 ML/day	50-70 ML/day (30 ML/day)	30 ML/day				

Flow component	Reach 1	Reach 2	Reach 3a	Reach 3b	Duration	Frequency and timing	Condition tolerances	Ecological objectives
Winter low flow (Wet /average years)	50-80 ML/day	30-40 ML/day	70-100 ML/day (50-80 ML/day)	40-50 ML/day	6 months Jun-Nov	Vary the magnitude of flow within the prescribed range throughout Jun-Nov to match the natural flow regime. Ramp the flow up slowly from June to deliver the highest magnitude in Jul-Sep, then gradually drop flow through Nov.	In wet years or in years when flow needs to be transferred downstream for system operation purposes the flow can be closer to the upper end of the recommended range for most of the season. The lower magnitude recommended for dry years is intended to save water so that other flow components can be delivered during the year. Need to avoid sudden and frequent fluctuations in low flow magnitude so that fish and other biota can respond without being stranded.	PF1.1, PF 1.3 SV1, SV2, SV3, SV4. PP1, SG2 SB1. SM1 SWQ1.
Winter low flow (Dry years)	35 ML/day	20 ML/day	50 ML/day (30 ML/day)	30 ML/day				
Winter fresh (wet years)	400 – 700 ML/day	200 – 400 ML/day	900 ML/day	450-900 ML/day	Jul-Aug event 1-2 days at peak In at least 2 out of 5 years the Sep-Oct event should have a 2-3 week duration including 4-5 days at peak. Ramp up over 3-4 days and ramp down over 7-12 days.	2 per year (1 in Jul-Aug & 1 in Sep-Oct) in average to wet years. Not expected in dry years, but ensure no more than 3 consecutive years without a winter fresh.	The vegetation objectives are likely to be met by an event that lasts only 1-2 days at peak, but the longer duration is needed to enhance Murray Cod breeding. Should not be delivered in November in consecutive years to avoid flushing River Blackfish nests or slackwater habitats that may support developing fish larvae.	PF1.2 PV1, SV1, SV2, SV3 PP1 SM1 SWQ2 SG1, SG2
Winter Fresh (Dry years)	NA	NA	NA	NA				

Flow component	Reach 1	Reach 2	Reach 3a	Reach 3b	Duration	Frequency and timing	Condition tolerances	Ecological objectives
Winter High Flow	500-1000 ML/day	1000 ML/day	1500 – 2000 ML/day	1500-2000 ML/day	10 days at peak to enhance Murray Cod breeding, but can achieve vegetation objectives if duration is 2 days at peak. Ramp up over 4-5 days and ramp down over 7-14 days.	1 event between late September and early November in two consecutive years every decade. This event could replace the second winter fresh in some years.	Two consecutive events in ten years	PF1.2 PV1, SV2, SV4 SWQ2. SG1, SG2, SG3
Bankfull flow	4000 ML/day	3000 ML/day	7300 ML/day	13000 ML/day	1-2 days at peak	Bankfull flow cannot be delivered with existing infrastructure therefore frequency and timing will be determined by natural floods that cause Cairn Curran Reservoir to spill.	The bankfull flow cannot be actively delivered with existing infrastructure and would almost certainly flood private land downstream of Loddon Weir.	PF1 PV1, SV4 SG1, SG3

Table 19: Flow recommendation for the mid Loddon River System except Serpentine Creek (Reaches 4a,4b,4c and 4d)

Flow component	Reach 4a	Reach 4b	Reach 4c	Reach 4d	Duration	Frequency and timing	Condition tolerances	Ecological objectives
Cease-to-flow	NA	NA	NA	NA	NA	Not recommended	Cease-to-flow events should be avoided where possible.	Likely to be detrimental to water quality, prevent re-colonisation by instream vegetation, limit macroinvertebrate productivity and therefore limit fish and platypus populations.
Summer low flow (Wet and average years)	50 ML/day	25 ML/day	25 ML/day	30 ML/day	6 months Dec-May	Vary the magnitude of flow within the prescribed range throughout Dec-May. Higher magnitude in Dec, gradual decline through Jan-Mar then gradual rise from Apr-May	Need to avoid sudden and frequent fluctuations in low flow magnitude to avoid disrupting slackwater habitats or stranding biota in habitats that are likely to dry.	PF2.1, PF2.3 SV1, SV2, SV3, SB1, SM1. SWQ1.
Summer Low Flow (Dry years)	25 ML/day	20 ML/day	5 ML/day	10-15 ML/day				
Summer fresh	50-100 ML/day	25-60 ML/day	25-40 ML/day	30-75 ML/day	3-4 days at peak. Ramp up over 1-2 days and ramp down over 3-4 days.	2-3 events per year: 1 event in Dec-Feb and 2 events Mar-May	The upper range of the recommended flows should be delivered whenever possible. Flows at the lower end of the range may be delivered in dry years as long as they provide a significant increase in depth and wetted width compared to the summer low flow at that time.	PF2.2, PF2.3 SV1, SV2, SV3, PP1 SG2 SB1. SM1.
Summer high flow	400 ML/day	~200 ML/day	~200 ML/day	~400 ML/day	3 weeks for whole event. Ramp up over 3-4 days, hold at peak for 6 days and gradually draw down over 10 days.	1 event in April-May in wet and average years. Not expected in dry years	No more than four years between events.	PF2.2, PF2.3 PP1 PV2, SV2, SV3 SG2

Flow component	Reach 4a	Reach 4b	Reach 4c	Reach 4d	Duration	Frequency and timing	Condition tolerances	Ecological objectives
Winter low flow	50-100 ML/day	25-60 ML/day	25-40 ML/day	30-75 ML/day	6 months Jun-Nov	Vary the magnitude of flow within the prescribed range throughout Jun-Nov to match the natural flow regime. Ramp the flow up slowly from June to deliver the highest magnitude in Jul-Sep, then gradually drop flow through Nov	The upper end of each flow range should be delivered in as many years as possible. In dry years, flows at the lower end of the range may be delivered provided they represent a significant increase in depth and wetted width compared to the summer low flow. Need to avoid sudden and frequent fluctuations in low flow magnitude so that fish and other biota can respond without being stranded.	PF2.3 SV2 PP1 SB1; SM1
Winter high flow	450-750 ML/day (The magnitude for this flow event will need to be based on the maximum flow that can be delivered without causing unwanted flooding on private land)	~225-375 ML/day	~225-375 ML/day	~450-750 ML/day	2-3 weeks with 7-10 days at peak between mid-September and late October. Ramp up over 3-4 days and ramp down over 5-10 days. Exact timing may need to be determined in consultation with affected landowners	1 event per year in wet and average years. Not expected in dry years	The high flow is mainly targeting floodplain vegetation and fish migration objectives and therefore needs to be delivered after mid-September when water temperatures and air temperatures begin to rise Ideally the event will be provided from the winter fresh or winter high flow events that are recommended for the reaches upstream of Loddon Weir.	PF2.2, PF2.3 PV1, PV2, SV2, SV3 SWQ1 SG1, SG2

Table 20: Flow recommendations for Serpentine Creek

Flow component	Wet / Dry	S1	S3	Duration	Frequency and timing	Condition tolerances	Ecological objectives
Cease-to-flow	-	NA	NA	NA	Not recommended		Likely to be detrimental to water quality, prevent re-colonisation by instream vegetation, limit macroinvertebrate productivity and therefore limit fish and Platypus populations.
Summer Low flow	Wet Ave	10 ML/day 20 ML/day	10 ML/day 30 ML/day		January to May December		PF1.1, PF1.3, PF1.4 SV1, SV2, SV3, SV4. PP1 SB1. SM1. SWQ1.
	Dry		5 ML/day 30 ML/day		Jan to May December		
Summer Fresh	Wet/ Ave	40 ML/day	30-40 ML/day		4 events		PF1 SV1, SV2, SV3, SV4. PP1 SG2 SB1, SM1. SWQ1.
	Dry	40 ML/day	30-40 ML/day		2 events	4 events in dry years when plants are establishing)	
Winter low flow	Wet / Average	30 ML/day	30-40 ML/day		Whole season		PF1.1, PF 1.3 SV1, SV2, SV3, SV4. PP1, SG2 SB1. SM1 SWQ1.
	Dry	20 ML/day	-			Whole season (but for no more than 3 consecutive years, after which time the flow should be raised to 30 ML/day for at least one year).	

Flow component	Wet / Dry	S1	S3	Duration	Frequency and timing	Condition tolerances	Ecological objectives
Winter Fresh	Wet / Average	120-150 ML/day	100 – 200 ML/day	2 days	1 event		PF1.2 PV1, SV1, SV2, SV3 PP1 SM1 SWQ2 SG1, SG2
	Dry	40 ML/day	Not expected	2 days	1 event	Increasing flow slightly in dry years provides important flow variability and flushes organic material from the bank to reduce risk of blackwater in summer, but it doesn't water plants on low benches. No more than 3 years without fresh in S3	
Winter high flow	Wet Ave	NA	>500 ML/day	2 days	2 events per year in 2 consecutive years	No more than 4 years without an event	PV1, PV2
	Dry	NA	Not expected				
Overbank	Wet/Ave	NA	>1000 ML/day[8]	2 days	2 events per year in 2 consecutive years	No more than 4 years without an event	PV1, PV2
	Dry	NA	Not expected				

[8] Expected to engage small areas of the floodplain

Table 21: Flow recommendations for the lower Loddon River System

Flow component	Pyramid	R5	Duration	Frequency and timing	Condition tolerances	Ecological objectives
Cease-to-flow	NA	NA	Not recommended	Not recommended	Cease-to-flow events may have occurred naturally in this reach, but are not recommended because the system has been degraded by altered flows and the objectives are to improve conditions over the short to medium term rather than provide specific stresses. Moreover, there are few deep refuge pools that can support large numbers of aquatic biota during cease-to-flow events.	Likely to be detrimental to water quality, prevent re-colonisation by instream vegetation, limit macroinvertebrate productivity and therefore limit fish and platypus populations.
Summer low flow	200 ML/day	60-100 ML/day	6 months Dec-May	Vary the magnitude of flow within the prescribed range throughout Dec-May. Higher magnitude in Dec, gradual decline through Jan-Mar then gradual rise from Apr-May	The aim will be to ensure a minimum flow of 60 ML/day at all times, but flows could increase to 100 ML/day for extended periods without creating too much velocity for developing fish in slackwater edge habitats. Avoid sudden and frequent fluctuations in low flow magnitude that may either flush biota from particular habitats as flows increase or strand them as habitats dry.	PF2.1, PF2.3 SV1, SV2, SV3, SB1, SM1. SWQ1.
Summer fresh	-	220 ML/day	2-3 days at peak. Ramp up to peak over 1-2 days and ramp down over 2-3 days. The whole event should last for approximately 1 week.	3 events per season: 1 between Dec and Feb 2 between Mar and May.	Do not actively deliver more than 1 fresh or a large fresh in Dec-Feb to avoid disturbing slackwater habitats during the main fish larval rearing phase. More frequent events are OK after February in any year and may help facilitate platypus dispersal.	PF2.2, PF2.3 SV1, SV2, SV3, PP1 SG2 SB1. SM1.
Summer high flow	900 ML/day	900 ML/day	10 days at peak. Ramp up over 5 days and ramp down over approximately 14 days	1 event in March – April in wet and average years Not expected in dry years	No more than 2 consecutive years without an event.	PF 2.2, PF 2.3

Flow component	Pyramid	R5	Duration	Frequency and timing	Condition tolerances	Ecological objectives
Winter low flow	200 ML/day 90 ML/day for short periods	200-220 ML/day May drop to 60 ML/day for short periods	6 months Jun-Nov	Vary the magnitude of flow within the prescribed range throughout Jun-Nov to match the natural flow regime. Ramp the flow up slowly from June to deliver the highest magnitude in Jul-Sep, then gradually drop flow through Nov.	June to August is not a critical time for fish movement and therefore any flow reductions for operational reasons should be restricted to that period. Flows should remain above 200 ML/day from September to November because migratory species such as Golden Perch and Silver Perch will be moving between upstream reaches and the Murray River. 90 ML/day in dry years will enable fish movement into Kow Swamp but not provide tail water at the bottom of the lock for fish moving out of Kow Swamp (not likely to be flow)	PF2.3 SV2 PP1 SB1; SM1
Winter fresh	900 ML/day	900 ML/day	10 days as peak. Ramp up over 5 days and ramp down over approximately 14 days.	1 event in September-October in wet and average years Not expected in dry years	Avoid more than two consecutive years without an event.	PF2.2, PF2.3 PV1, PV2, SV2, SV3 SWQ1 SG1, SG2
Bankfull flow	NA	2,000 ML/day	3-4 days at peak	3-4 per decade, but no more than 1-2 events per decade during the Platypus breeding season (i.e. August-March).	It will be difficult to deliver a flow of this magnitude in the Lower Loddon River with existing infrastructure. Even if it can be delivered, the magnitude will probably need to be capped to limit the risk of unwanted flooding on private land.	PF1.2, PF1.3 SV1, SV3, SG1, SG2

7 Ten year regime

Historically river systems have been managed according to annual flow recommendations. However, to achieve long term objectives flow regimes need to be adaptable and variable from one year to the next. To meet the 'long-term' requirements of the upper and lower Loddon River System and Serpentine Creek, a ten year flow regime has been established considering the following factors and is shown in Table 22:

- the recommended number of watering events over a ten year period for a particular objective; and
- the tolerable intervals between events (condition tolerances)

It should be noted that the ten year watering regime is assuming water availability and will need to be adaptively managed and be based on outcomes achieved in the previous year. Adaptive management principles should consider the condition tolerances shown in Table 18 to Table 21.

A 'seasonally adaptive' approach has been adopted for the management of environmental water in Victoria. This approach identifies priorities for environmental watering based on the amount of water available in a given year, and recognises short-term climatic variability to help guide and manage annual watering priorities. The process involves considering the minimum flow components (and related water volumes) needed to meet ecological objectives and what additional objectives and flow components can be added as inflow increases and environmental water availability increases. A key consideration when developing scenarios in the Loddon River System is the combined volume of water in Tullaroop and Cairn Curran Reservoirs. If combined storage drops below 60 GL the passing flow rates drop to a lower level, and this has implications for the volume of water required for each flow component (North Central CMA 2015b).

Reach 4a in the Loddon River has a constrained bankfull capacity of 450 ML/day. This capacity restricts the ability to deliver high flows in the other river reaches. As such, assuming water availability, the flow recommendations for Reach 4 (with a lower flow range of 450 ML/day) is likely to be met annually. The resolution of operational constraints over the next ten years will facilitate delivery of the higher volume flow recommendations in the upper Loddon River.

Table 22: Ten year water regime for the upper and lower Loddon River and Serpentine Creek (assuming water availability)

Year	1	2	3	4	5	6	7	8	9	10
Focus objectives	Successful native fish/Platypus recruitment	Successful native fish/Platypus recruitment	Successful native fish/Platypus recruitment	River Red Gum Recruitment	Follow up watering for River Red Gum recruitment	Successful native fish/Platypus recruitment	Successful native fish/Platypus recruitment	Successful native fish/Platypus recruitment	Successful native fish/Platypus recruitment	Successful native fish/Platypus recruitment
	Establish instream /emergent vegetation	Establish instream /emergent vegetation	Establish instream /emergent vegetation			Maintain instream /emergent vegetation	Maintain instream /emergent vegetation	Maintain instream /emergent vegetation	Maintain instream /emergent vegetation	Maintain instream /emergent vegetation
Summer Low Flow	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Summer Fresh	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Winter Low Flow	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Small Winter Fresh										
July-Aug	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Sept-Oct	✓	✓	✓			✓	✓	✓	✓	✓
Winter high flow				✓	✓					
Bankfull/Overbank	Review if operational constraints are overcome									

8 Risk Assessment

A qualitative risk assessment has been undertaken to assign the level of risk of threats to achieving the objectives as well as risks related to the delivery of environmental water through the implementation of this EWMP. The relationship between likelihood (probability of occurrence) and the severity (severity of the impact) provide the basis for evaluating the level of risk (Table 23).

Table 23: Risk assessment matrix

		Severity		
		Major	Moderate	Minor
Likelihood	Probable	High	High	Moderate
	Possible	High	Moderate	Low
	Improbable	Moderate	Low	Low

The results from the Loddon River System risk assessment are presented in Table 24. Management measures relevant for the moderate to high level risks are recommended and the residual risk is then recalculated using the same risk matrix. Please note that short-term operational risks (e.g. environmental releases causes flooding of private land) are assessed as part of the development of the Loddon River System Seasonal Watering Proposal.

Table 24: Risk assessment and management measures

NB: R = Risk, RR = residual risk

	Threat	Impacts	Relevant objective	Likelihood	Severity	R	Management Measure	RR
Threats to achieving ecological objectives								
1	Cold water pollution from deep water offtakes in storages	Cold water pollution from dams that have offtake points in deep water is a major cause for the decline of many native freshwater fish species and is likely to impact aquatic biota for example cold water changes macroinvertebrate community structure, slows growth rates of fish, lowers rates of productivity and some fish may not spawn if temperatures are too low (DSE 2003). The impact of cold water pollution can be evident hundreds of kilometres downstream of storages. The status of water temperature downstream of Cairn Curran, Tullaroop and Laanecoorie Reservoirs is uncertain. It has been suggested these reservoirs may release colder than natural water and the 2002 flows study suggests that further investigation is required (LREFSP 2002a).	SWQ1	Probable	Major		Further analysis of the degree and impact of cold water and hypoxic water releases from the three storages will inform the need for future modification of offtake structures to manage this issue. Residual risk is calculated on required upgrades reducing the likelihood to improbable.	

	Threat	Impacts	Relevant objective	Likelihood	Severity	R	Management Measure	RR
2	Artificial instream structures (i.e. Weir walls at the major storages and weirs, gauging stations at Loddon Weir and Appin South and lower level crossings and barriers)	*Longitudinal Connectivity* Instream barriers restrict: • downstream movement of plant propagules and the source of seeds or plant fragments required for the recolonisation of areas denuded by recent floods. • downstream movement of carbon and nutrient inputs especially coarse and fine particulate organic matter because leaf litter inputs are generally highest in headwater reaches. • upstream and downstream movement by fish between the reaches, causing issues such as genetic isolation and restricting spawning opportunities for migratory species such as Golden Perch and Silver Perch. • movement by Platypus that are then exposed to higher risk of predation if forced to travel overland to move between reaches. • recolonisation between river reaches when aquatic species are affected by some sort of disturbance (O'Brien et al. 2006).	PF2, PF3, PF5 PP1, PP2 PV1, SV1, SV2	Probable	Major		Major structures (Loddon Weir, Serpentine Weir) and a number of minor structures will need to be upgraded for fish passage. Residual risk calculated on full passage upgrades reducing the likelihood to improbable. Construction of fish passage is already underway or planned for Box Creek regulator and the Chute.	

	Threat	Impacts	Relevant objective	Likelihood	Severity	R	Management Measure	RR
3	Grazing pressures	The Loddon River features mostly continuous native tree canopy, however this primarily comprises large old trees, predominantly River red gums. 46% of the Loddon River is currently fenced or otherwise protected. The same statistic for Serpentine Creek is 20% and Pyramid Creek 15%. Grazing by domesticated, feral and/or native herbivores (e.g. cattle, sheep, rabbits, kangaroos and wallabies) may prevent establishment of emergent vegetation on benches and recruitment of understorey and overstorey species within the riparian zone. This may be caused by direct grazing pressure (most likely) or sediment pugging (less likely). Submerged and emergent aquatic vegetation may also be impacted by grazing and physical disturbance.	Pv1, PV2, SG1, SG2 SWQ1	Probable	Major		Fencing and stock exclusion have demonstrable benefits to riparian vegetation. Continue delivery of riparian protection programs with landholders as was previously undertaken via the Loddon Stressed River and associated projects. Provide ongoing extension and support services to participating landholders and undertake monitoring and compliance programs. Residual risk is assessed assuming delivery of such a project and that increasing lengths of the Loddon are protected.	
4	Introduced species - Common Carp	High abundance of Common Carp limits the establishment and subsequent maintenance of in-stream (submerged) vegetation with flow on affects to the entire food web. Carp also feed at lower trophic levels in the food web along with macroinvertebrates and small bodied fish, yet they are long lived and grow very large, effectively locking up large amounts of carbon that would flow up the food web and support higher trophic levels in natural systems. Carp are well distributed throughout the Loddon River (Jacobs 2014f).	PF1, PF2, PF3, PF4, PF5, PF6 SF1, SF2	Possible	Moderate		There is yet to be a broad scale successful method for controlling Common Carp biomass which is a knowledge gap across the Murray-Darling Basin. The Loddon River System should be managed to provide favourable conditions for native fish species (e.g. amelioration of cold water conditions, removal of instream barriers, management of flows to favour native fish migration and breeding needs) and where possible flows should be managed to disfavour conditions favourable to Carp.	

	Threat	Impacts	Relevant objective	Likelihood	Severity	R	Management Measure	RR
5	Introduced species – Gambusia/ Redfin	Eastern Gambusia has been linked to the decline in distribution and/or abundance of small bodied fish such as Murray-Darling Rainbowfish, Olive Perchlet and Purple Spotted Gudgeon through competition for food and habitat. Research has also indicated that larger predatory fish species such as Murray Cod and Golden Perch actively avoid Eastern Gambusia as a prey item (Macdonald & Tonkin 2008). Redfin Perch is a predatory fish and preys on small bodied fish. Redfin Perch have not been declared noxious pest in Victoria. Anglers are encouraged not to return this species to rivers if captured. Gambusia, Goldfish and Redfin Perch are well distributed throughout the Loddon River (Jacobs 2014f). Other exotic species known to occur in the Loddon system, though not widespread, are Tench and Oriental Weatherloach. Tench are not considered to present a significant risk to native species. Oriental Weatherloach have a range of biological characteristics that make it a successful invader though its ecological impacts are poorly understood, as are control of containment methods (Koster et al. 2002).	PF1, PF2, PF3, PF4, PF5, PF6 SF1, SF2	Probable	Major		Research indicates that traps that exploit Eastern Gambusia's attraction to light and heat may maximize capture of eastern Gambusia while having a minimal impact on native fish (Macdonald & Tonkin 2008). Residual risk is assessed recognising that other than anglers removing all catches from system the threat of Redfin Perch cannot currently be managed however the threat of Eastern Gambusia numbers can be managed. Management actions will reduce the abundance of Eastern Gamusia, but that recolonisation from the Murray River is possible and that the spatial severity (i.e. recolonisation is managed) is moderate.	
6	Introduced species - Foxes	Predation on Platypus and other aquatic fauna such as freshwater turtles that can leave the water and are vulnerable to predation when travelling through very shallow water or across dry land.	PP1, PP2	Possible	Moderate		Managing this risk relates to improving riparian cover and longitudinal aquatic connectivity as well as fox control programs. Residual risk is assessed assuming full implementation of these measures reducing likelihood to improbable	

	Threat	Impacts	Relevant objective	Likelihood	Severity	R	Management Measure	RR
7	Administrative rules around availability of water for environmental delivery	Delivery of water is mistimed to suit optimal conditions for ecological objectives e.g. fish and platypus breeding and migration cycles	ALL	Probable	Moderate		North Central CMA to work with DELWP and VEWH to explore options to modify administrative rules in order to provide for maximum flexibility for environmental water delivery whilst meeting operational and consumptive needs. Residual risk is assessed assuming collaboration towards achieving maximum flexibility in administrative rules reducing likelihood to improbable.	
8	Poor community support and understanding of the benefits of environmental watering, particularly in times of drought.	Ministerial office receives community complaints and pressure. North Central CMA corporate reputation is compromised.	ALL	Possible	Moderate		North Central CMA and other agencies maintain a prime focus on engaging, informing and educating community and water users on the objectives, uses and mutual benefits of environmental water delivery. Fostering champions and stewardship for environmental water. Undertaking media campaigns to promote the nature and benefits of environmental watering. Residual risk is assessed assuming broad community understanding and acceptance of environmental water. Likelihood remains at possible however severity reduces to minor.	
9	Unauthorised diversion of low flow environmental releases in Loddon reach 4.	Recommended summer low flows for reach 4 for are 25ML / day (SKM 2010c). This is a particularly long reach with associated high summer losses. Delivery of recommended summer low flows in this reach might be constrained by a lack of control over unauthorised diversions (SKM 2006).	ALL	Probable	Moderate		Monitor all diversion sites to prevent unauthorised diversions Residual risk assumes these measures will reduce incidence of unauthorised diversions and the likelihood will be reduced to possible.	

	Threat	Impacts	Relevant objective	Likelihood	Severity	R	Management Measure	RR
10	High nutrient runoff from land management practices	High nutrient loads in waterways and reservoirs can result in blue green algal blooms with a resultant impact on aquatic life and the quality of consumptive water. Excessive algal growths can also initiate oxygen depletion events with an impact on aquatic life (Lloyd et al. 2008). Nutrients enter waterways from adjacent land via a number of pathways, runoff from excess nutrient application to crops and pastures, streambank and gully erosion, animals fouling in waterways, sediment runoff from adjacent land and poorly managed agricultural chemical use (Department of Health 2008).	PV1, PV2 SV 1 – 4 SM1 SWQ1	Probable	Major		North Central CMA and other agencies work with landholders and the Landcare movement to promote and foster good land management practices such as frontage management revegetation, stock exclusion, creation of riparian buffer zones and wise nutrient management. Residual risk assumes that extension and education activities are ongoing and well adopted by landholders. Over time the likelihood would reduce to possible and severity to moderate.	
11	High instream salinity via input from specific waterways (Bet Bet, Pyramid and Barr creeks), groundwater intrusion and releases from reservoirs when storage volumes are low.	High salinity levels can impact on aquatic ecosystems affecting both flora and fauna and also affect the quality of consumptive water.	PF1-6 PP1, PP2 PV1, PV2 SV1-4 SF1, SF2 SM1 SWQ1	Possible	Moderate		Monitoring of salinity levels instream and in storage to be aware of rising salinity levels. Utilise available water to dilute flows at times of rising salinity. GMW to manage interception schemes in Barr and Pyramid creeks to avoid high salt loads entering waterways. Residual risk assumes these measures will reduce likelihood of high salinity levels however this is highly subject to a range of factors including seasonal conditions and groundwater trends.	

	Threat	Impacts	Relevant objective	Likelihood	Severity	R	Management Measure	RR
12	Irrigation water delivery	Rapid flow fluctuations during the irrigation season that reduces habitat suitability for native fish and in-stream vegetation by disrupting slackwater habitats or stranding biota in habitats that are likely to dry.		Probable	Major		Work with Goulburn Murray Water to include the avoidance of sudden and frequent fluctuations in flow magnitude as part of operational protocol. Residual risk reduces	
Threats related to the delivery of environmental water								
12	High flow levels impacting on Platypus Winter high fresh	High flow levels of extended duration can substantially reduce Platypus reproductive success from the time that females incubate eggs (starting in September) through at least the end of February. A lactating female blocks the tunnel leading to her nesting chamber with soil 'pugs' to protect her offspring from drowning if water levels rise for a short period. However, this measure will be ineffective if flows persistently remain above the level of the nesting chamber. A high winter fresh could inundate burrow entrances drowning juvenile Platypus	PP1, PP2	Possible	Moderate		Freshes scheduled in spring or summer should be coupled to a preceding event of similar or greater magnitude in August, i.e. around the time that breeding females are choosing nursery burrow sites, to encourage females to locate nesting chambers above the maximum height of the subsequent fresh. Deliver winter high fresh in August to trigger female to select or construct nursery burrows higher in the river bank. Residual risk is assessed assuming likelihood of burrows being flooded as improbable.	

	Threat	Impacts	Relevant objective	Likelihood	Severity	R	Management Measure	RR
13	Mobilisation of accumulated leaf litter following extended period of low to no-flow conditions	Low dissolved oxygen associated with the breakdown of high loads of accumulated leaf litter generally occurs when ephemeral streams are inundated or when high flow events wash large amounts of leaf litter into the river from the adjacent bank, benches and floodplain. Microbes rapidly consume the available carbon and their respiration severely depletes oxygen levels in the water column. Microbial activity is higher in warm temperatures and is also governed by the amount of available organic material (SKM 2010b).	PF1-6 PP1, PP2 SV1-3 SF1, SF2 SM1 SWQ1	Improbable	Major		The three factors that determine the likelihood and severity of a blackwater event are the magnitude of the high flow or re-wetting event, the timing of that event and the amount of accumulated organic material. Management option is to ensure adequate winter low flows and frequent high flow events to entrain leaf litter into the channel avoiding build up to excessive levels and to deliver a summer fresh at the same magnitude as the previous winter low flow which will entrain only litter that has built up since the winter low flow was ceased (SKM 2010c). Residual risk assumes that the management action will reduce the spatial extent of the risk, reducing the severity to minor. Further research is required to understand the leaf loading threshold on river banks in reaches where blackwater events may be possible.	
14	Consistent flows to a depth of 15 to 30 cm in Reach 4	Consistent flows at this depth coupled with a rich nutrient base are likely to foster the growth of instream macrophytes such as *Typha* species (cumbungi). There are currently low levels of *Typha* in the Loddon River. There is a risk that they may colonise beyond the margins of the waterway and dominate the channel width with a resultant obstruction to fish passage and loss of longitudinal connectivity in the river as has occurred in the past.	SV4	Possible	Moderate		Management options include maintaining sufficient flow levels in reach 4 to mobilise sediments and ensure appropriate depths to discourage excessive macrophytes growth, work with local landholders and North Central CMA staff to monitor shallow sections for excessive *Typha* growth and review flow regimes if excessive growth becomes apparent. Residual risk assumes that the management actions are implemented and applied adaptively reducing likelihood to improbable.	

9 Environmental water delivery infrastructure

9.1 Constraints

The following section outlines the constraints to delivering environmental water in the Loddon River System.

9.1.1 Infrastructure Constraints

Outlet capacity of the storages

Delivery of the recommended bankfull flow of 4,000 ML/day in Reach 1 is restricted by the delivery capacity of two outlet structures on Cairn Curran Reservoir, a needle valve outlet used for delivering irrigation water and the power station outlet, which have a combined capacity of 1,600 ML/day. The maximum combined flow rate is constrained by a number of factors including:

- Water levels in Cairn Curran – the outlet tower has 14 portals that receive water from the water column, as water level drops below these the flow rate from the tower is reduced.
- A generator is required to deliver flows greater than 220 ML/day, which is currently in disrepair. AGL, the energy company that owns the power station outlet has indicated that it will be repaired, however the timeframe for this is not currently known (Farnsworth, D 2015, personal communication, [GMW Senior Reservoir Controller], 2 February).

Cairn Curran also has three radial flood gates that have a combined discharge capacity of 189,000 ML/day (DEPI 2014e). There is potential to operate these for delivering higher flows, however the feasibility of this, particularly related impacts on the operation of Laanecoorie Reservoir needs to be investigated (Farnsworth, D 2015, personal communication, [GMW Senior Reservoir Controller], 2 February).

The winter high flow of 1,000 ML/day and bankfull flow of 3,000 ML/day in Tullaroop Creek (Reach 2) are constrained by the outlet capacity of Tullaroop Reservoir which is approximately 660 ML/day. GMW manages two portals in the Tullaroop Reservoir outlet tower. Central Highlands Water (CHW) operates three portals and this water is diverted from the reservoir to the CHW treatment plant. The GMW portal at the top of the outlet tower has a greater delivery capacity than the lower GMW portal, therefore once the water level in the reservoir drops below the top portal the delivery capacity to Tullaroop Creek drops to approximately 220 ML/day (Farnsworth, D 2015, personal communication, [GMW Senior Reservoir Controller], 2 February).

Instream barriers

A number of instream barriers prevent connectivity throughout the Loddon River System at various flows. These include all the structures, with the exception of Kerang Weir, the Chute and the Box Creek Regulator (once the fish way has been constructed), described in Section 3.3**Error! Reference source not found.**, as well as smaller structures such as road crossings and gauge weirs shown in Table 25.

Table 25: Instream barriers of the Loddon River System

Structure	Reach	Flow component impeded[9]
McQuillan Road crossing in Reach 3a (O'Brien et al. 2006);	Reach 3a	Low
Loddon Weir stream gauge just downstream of Loddon Weir in Reach 4a (O'Brien et al. 2006)	Reach 4a	Low
Ellerslie Road crossing in Reach 4a (O'Brien et al. 2006; Stuart 2012)	Reach 4a	Low
Appin South stream gauge is a low level barrier within this reach (O'Brien et al. 2006; Stuart 2012).	Reach 4d	Low
Knife Edge Weir on Serpentine Creek Reach S1 (O'Brien et al. 2006).	Reach S1	Low
Private track crossings (Reach 4b and Reach 4c) (Jacobs 2015a)	Reach 4b and 4c	Low

[9] Magnitude not known

9.1.2 Operational constraints

A number of operation constraints exist in the Loddon River System that impact the ability to deliver environmental flows.

Flow in Reaches 1 and 2 are impacted by the operation of Laanecoorie Reservoir, which is currently based on responding to the water level in Laanecoorie. Over summer this results in summer low flow being interrupted much more frequently than the summer fresh recommendation (Farnsworth, D 2015, personal communication, [GMW Senior Reservoir Controller], 2 February). There is opportunity to work with GMW to build in the optimal timing and frequency for summer freshes into an operation plan for the upper Loddon River (Shields, A. 2015, personal communication, [GMW Manager River Operations], 13 May).

Bankfull capacity in Reach 4 is 450 ML/day in some areas (North Central CMA 2015c). Therefore delivery of flows higher than this in upstream reaches would likely result in overbank flow in Reach 4. There are opportunities to deliver water from Serpentine Weir and Loddon Weir onto the floodplain, including delivering flow recommendations in Serpentine Creek, that either re-enter the Loddon River downstream of Canary Island or be used for other purposes (e.g. watering wetlands) (Cameron, L 2015, personal communication, [GMW Customer Service Co-Ordinator] 10 March), however a feasibility study of these options is required.

Delivery of water from the Waranga Western Channel, downstream of Loddon Weir, is constrained by capacity in the channel on top of irrigation demand. This may impact on the ability to achieve flow recommendations when the source of water is the Goulburn System (Cameron, L 2015, personal communication, [GMW Customer Service Co-Ordinator] 10 March).

Delivery of the high flow recommendation of Pyramid Creek operation capacity is 1000 ML/day and the end point for this water is usually the Kerang Lakes (Mason, K 2015, personal communication, [GMW Customer Service Co-Ordinator], 10 March). It is possible that this will impact the ability to provide environmental flow of 900 ML/day that needs to flow from Pyramid Creek to Reach 5 to trigger movement of fish from Reach 5 (Murray River) into Kow Swamp. Further investigation is needed to understand the operation capacity and determine if options such as increasing the operational capacity or operating the Kerang Lakes differently to enable the delivery of the autumn and spring high flow are feasible.

9.2 Infrastructure recommendations

Cairn Curran, Tullaroop and Laanecoorie outlet capacity

Delivery of high flows would be enhanced by increasing the outlet capacity of the main delivery storages. To date there has not been any investigation into the feasibility of increasing delivery capacity from these storages and further work is required.

Removal of instream barriers

In 2006, Appin South Stream Gauge, Ellerslie Road crossing, and McQuillan Road crossing were nominated as the highest priority barriers for removal or retrofitting with fish passage (O'Brien et al. 2006). This would facilitate fish movement throughout these reaches by smaller fish throughout the year and larger fish during spring freshes (O'Brien et al. 2006). Costing the removal or retrofitting of these structures is required.

Further work was recommended to undertake cost benefit analysis for retrofitting the larger weirs and the structures in Serpentine Creek for fish passage (O'Brien et al. 2006)

10 Complementary actions

Implementation of the above watering regime for the Loddon River System will generate benefits to the environmental values of the river. Some objectives require complementary actions to be realised. These are directly related to the risk section, i.e. risk of not achieving objectives (see Table 26).

The Loddon Stressed River project involved community engagement, on-ground activities (riparian fencing, revegetation, erosion control and woody weed management), in-stream habitat restoration and investigations and research. Riparian fencing protected 390 km of river frontage and riparian vegetation, equivalent to 56% of total frontage in the project area. Habitat restoration for river blackfish and Loddon River fish communities was completed at sites in Loddon River (Reach 1), Tullaroop Creek and Pyramid Creek. Additionally, over the last five years of the project 600 ha riparian vegetation was protected and improved with revegetation, 8 erosion control structures were installed and 74 ha of riparian vegetation was protected by willow and other woody weed removal. Investigative studies improved regional understanding of fish communities and were instrumental in attracting funds for future fish habitat and migration projects (North Central CMA 2014b). Continuation of a similar riparian and waterway protection program is considered a major complementary activity to support environmental water delivery.

The North Central CMA has recently developed the Native Fish Recovery Plan – Gunbower and Lower Loddon (Mallen-Cooper et al. 2014). This is a long term plan to restore ecosystems, fisheries and tourism in the Gunbower and lower Loddon system by restoring loss of connectivity for fish movement and migration, addressing the changes in natural flows regimes and reversing the loss of instream habitat. Activities to be delivered under this plan include installation of fishways on key barriers, installation of fish protection screens on irrigation channels and offtakes, instream habitat rehabilitation and riparian protection and revegetation. Environmental flows are a key component of this plan and will be mostly integrated into existing irrigation water deliveries. Delivery of environmental flows and complementary works on the lower Loddon and Pyramid Creek are critical components of the Native Fish Recovery Plan.

Table 26: Complementary measures to enhance outcomes of environmental watering

Activity	Rationale
Undertake further investigation into impacts of cold water release from storages and investigate options to release ambient temperature water from storages.	Cold water pollution impacts native fish through creating conditions unsuitable for spawning. A clearer understanding of the impacts of cold water in the Loddon system is required.
Installation of fish passage on Loddon Weir and Serpentine Weir.	Upgrading these instream barriers would facilitate fish passage across the Loddon system, enhancing native fish genetic interaction, allowing fish to have access to a greater variety of habitat, and would facilitate colonisation after a severe disturbance.
Modification or removal of low levels weirs in the lower Loddon River to allow for fish passage.	This would support the movement of fish, including small bodied fish, throughout the system particularly at times of low flow.
Continue delivery of riparian fencing and protection programs (fencing, off stream watering, revegetation) with landholders adjoining the waterways.	Much of the waterway frontage is unprotected from stock access and lacks vegetative cover. Riparian protection has multiple benefits including removal of stock grazing pressures, reduced erosion, improved water quality and enhanced recruitment of native riparian and aquatic vegetation.

Activity	Rationale
Undertake an extension and auditing program with frontage landholders.	Maximum participation from landholders in riparian programs will be achieved by provision of information, understanding and support for their works. This will need to be supported by an auditing program to monitor outcomes and review compliance with agreed Riparian Management Agreements; this should be delivered to past and future participants in such programs.
Reinstatement of instream habitat in key reaches of Loddon system	Historical removal of habitat from waterways has resulted in some reaches of waterways providing poor instream habitat for fish and aquatic species. Reinstatement of instream woody habitat and aquatic vegetation will provide suitable habitat for migration, feeding, spawning and nursery areas for fish, platypus and other aquatic species.
Re-creation of deep pools in Loddon River reaches 4b, 4c and 4d.	Low flows and sedimentation in the lower Loddon has resulted in the loss of deep pools in these reaches of the river. Deep pools are a critical component of instream habitat and provide refuge in times of drought. It is possible to recreate deep pools using suitable techniques.
Undertake fox control measures	Foxes are likely to predate Platypus or freshwater turtles when these animals are in shallow water or moving across land. Fox control measures include baiting and interactive fox drives.
Work with irrigators to fit exclusion devices to irrigation pump intakes.	Pump intakes are known to entrap fish, platypus and turtles with resulting mortality and impact on the viability of populations.
Work with fish ecologists and research bodies to explore and undertake Carp control measures	Common Carp dominate the system; they have the largest biomass of all fish in the Loddon. A truly effective carp control measure is yet to be devised, however carp screens on fishways and education interactive activities such as "catch a carp" may help.

11 Demonstrating outcomes

Monitoring is required to demonstrate that watering is achieving long term environmental outcomes. Monitoring is also a critical component of the adaptive management of Loddon River System.

Two types of monitoring are recommended to assess the effectiveness of the proposed water regime on objectives and to facilitate adaptive management:

- Long-term condition monitoring
- Intervention monitoring

Currently the principle monitoring program for the release of environmental water on the Loddon River System is the VEFMAP program. The State is has recently reviewed the VEFMAP program which will inform the next phase of environmental watering monitoring is uncertain.

The monitoring program below is specifically related to demonstrating achievement of the short and long-term objectives of the Loddon River System EWMP and is derived expert advice from the Loddon River EFTP (Jacobs 2015a) and adapted from technical work undertaken for the development of the Campaspe River EWMP (North Central CMA 2014c)

11.1 Long-term condition monitoring

Long-term condition monitoring will provide information on whether the watering regime (and other factors) is causing a change in, or maintaining, the overall condition of the river (trend over time).

Current long-term condition monitoring

Funding has been confirmed under the VEFMAP program for fish surveys for the next two years (2015, 2016) and vegetation surveys in 2016, however funding for monitoring beyond this time is unconfirmed.

Required long-term condition monitoring

The long-term condition monitoring requirements that will demonstrate changes in condition over time specifically focusing on demonstrating the long-term outcomes of the Loddon River System EWMP is shown in Table 27.

Table 27: Required long-term condition monitoring for the Loddon River System

Objective	Method	When
1. Maintain Increase River Red Gum 2.2 Increase extent/maintain emergent littoral vegetation 2.3 Increase extent/maintain aquatic plants	Comprehensive vegetation condition surveys, including tree health, EVC condition, species presence, weediness and evidence of recruitment.	Years 2, 6, 10
2. Fish (Increase abundance and appropriate age classes)	Large bodied fish - targeted electrofishing fish surveys	Ideally annual No more than 2 years between surveys
	Small bodied fish - small mesh gauge fyke nets	Ideally annual No more than 1 year between surveys
2.1 Macroinvertebrates – functional groups	Method such as the Rapid Bioassessment protocol – surveys undertaken by QA/QC trained and funded Waterwatch, analysis undertaken by biologist	Twice yearly
2.1 Macroinvertebrate biomass	Best available science	TBD

Objective	Method	When
3. Platypus	Qualitative surveys – community based (Waterwatch) – analysis by biologist	Year 5, 10.
2.4 Water Quality	Continuous physicochemical monitoring	Continuous
5. Connectivity	Measuring discharge/level	Continuous

11.2 Intervention monitoring

Intervention monitoring will assess the responses of key environmental values to the changes in the water regime (intervention) and the achievement of ecological objectives e.g. to increase the extent of instream and emergent vegetation. Intervention monitoring may include monitoring of water quality, vegetation and biota (i.e. native fish).

Monitoring the response to a watering event will be important to provide feedback on how the system is responding and whether any amendments need to be made to the operational management or determine if any risk management actions need to be enacted.

Current intervention monitoring

The North Central CMA conducts an ongoing environmental flow water resource planning program for the Loddon River System, which is undertaken as part of the implementation of the Seasonal Watering Proposal. Each year environmental flows are released based on an assessment of the monitoring data as well as the water availability.

The internal CMA monitoring program is relatively limited and does not adequately cover the suite of ecological objectives and their response to flows. Appendix 7 provides more information on the current monitoring sites and photo points.

Required intervention monitoring

Further intervention monitoring is required so that the CMA is able to adaptively manage the river over the next ten years to ensure that the delivery of environmental water is achieving objectives. The proposed intervention monitoring program and the objective that is being monitored is shown in Table 28.

Table 28: Required intervention monitoring for the implementation of the Loddon River System EWMP

Objective	Monitoring question	When	Event	Method
Increase extent and maintain instream aquatic vegetation and emergent littoral macrophytes	Is instream and emergent vegetation responding to flows?	Year 1 and 2[10]	Summer fresh	Vegetation surveys– survey sites should include areas along the river that have been fenced and an agreement with landholder to exclude stock has been reached as well as sites with grazing pressure.
Maintain adult River Red Gum trees and facilitate successful recruitment	Are River Red Gum trees recruiting after November winter fresh	Year 3 and 4[11]	Large winter fresh (November event) Follow up large winter fresh event	Photopoints
Increase population size (with an appropriate age structure) of native fish	Are native fish spawning in slackwater?	Until we know	Summer low flow Also after winter fresh if in November or Summer Fresh if in Dec/Jan	Larvae sampling of slackwater – detail TBD
Facilitate recolonisation by native species that are presumed lost from the river	Are source populations of fish currently presumed lost from the river connected to the Loddon River	Year 1 and follow up Year 5	All events (Fishway)	Options could be netted surveys at fishway or investment in acoustic fish transponder and tagging project – detail dependent on budget and TBD
Risk				
Drowning Platypus burrows during November winter fresh	Is the August winter fresh encouraging Platypus to place their breeding burrows higher in the bank?	(whenever November fresh is intended)	After August fresh	Survey height of burrow entrances relative to mAHD
Hypoxic blackwater event risk from managed summer events?	Are dissolved oxygen levels maintained at acceptable concentrations during summer fresh?	Each year	Summer fresh	Continuous dissolved oxygen

[10] Instream and emergent vegetation intervention monitoring will need to occur in the first two years as a minimum, additional in-stream and emergent vegetation intervention monitoring will be required if response isn't as expected.
[11] Assumption that ten year flow regime proposed in this EWMP is followed. The actual timing will be dependent on adaptive management.

12 Knowledge gaps and recommendations

The Loddon River System EWMP has been developed using the best available information. However, a number of information and knowledge gaps exist which may impact on recommendations and/or information presented in the EWMP. These are summarised with priority status in Table 29.

Table 29: Knowledge and recommendations

Knowledge Gap	Specific reaches	Objective/ Risk	Recommendation	Who	Priority
Objectives					
Determination of the most appropriate month for delivery of a fresh (November to February) to ensure maximum native fish recruitment.	All	PF 1-6 SF1, SF2	An honours or PhD research project could monitor recruitment response after delivering freshes at different times.	North Central CMA/Research body	High
How well and quickly littoral plant species recover after stock exclusion / fencing is undertaken.	All	PV2 SV1, SV2, SV4	Establish a monitoring trial with trial plots and photo points.	North Central CMA/Research body	Medium
Develop better understanding of what ecological response there has been to environmental water delivery.	All	ALL	Develop a research project to better understand ecological response to past environmental water delivery	North Central CMA/Research body	High
The most appropriate operational model for North Central CMA and GMW in the delivery and management of water as the CMA and environmental water delivery become greater players in water management.	All	ALL	North Central CMA and GMW work together to develop operational guidelines.	North Central CMA and GMW	High
Status of FFG listed Freshwater Catfish in Reach 1	Reach 1	-	Include Reach 1 in VEFMAP surveys	North Central CMA	High
The impact of summer irrigation releases on River Blackfish spawning.	Reach 2 (Tullaroop), Serpentine Creek	PF4 SF1	Commission a study into environmental and flow constraints on River Blackfish spawning.	Research body or consultants	High
Current abundance and density of instream woody habitat in Loddon u/s of Macorna Main Channel, Tullaroop Ck, Serpentine Ck, Loddon River d/s of Kerang Weir	Loddon reaches 2, 4 & 5, Serpentine	PF1 – 3 PF6 PP1, PP2 SF1, SF2	Utilise Arthur Rylah Institute's *Victorian instream woody habitat assessment* tool to identify reaches in most need of rehabilitation activities. Engage consultants to undertake validation survey as per technique utilised by Arthur Rylah Institute on the Pyramid Creek.	North Central CMA / Research body or consultants	Medium
Develop better understanding of flow split between Loddon River reach 4c and Twelve Mile Creek Reach 4b at a range of different flow levels.	Loddon 4b & 4c	ALL	Commission a hydrological study on the flows and transmission losses in Reach 4 of the Loddon.	Consultants	Medium

Knowledge Gap	Specific reaches	Objective/ Risk	Recommendation	Who	Priority
Develop a better understanding of transmission losses in the Loddon River between Loddon Weir and Kerang Weir	Loddon 4a to 4d	ALL	Commission a hydrological study on the flows and transmission losses in Reach 4 of the Loddon.	Consultants	Medium
Understanding the effectiveness of deep pool re-creation on stream geomorphology, stability and habitat values.	Loddon reach 4a - d	SG1	Research based on experiences of other SE Australian CMAs (e.g. Goulburn Broken, Glenelg Hopkins or East Gippsland).	North Central CMA	High
Comprehensive understanding of stream flow and water quality in Serpentine Creek.	S1, S3	SWQ1	Commission water quality and flow gauging stations in reaches 1 & 3 of Serpentine Creek to ensure flows meet minimum flow depths and acceptable water quality conditions.	North Central CMA	High
Comprehensive understanding of freshwater turtles and frogs inhabiting the Loddon River System.	All reaches	ST1, SA1	Undertake faunal surveys including: • Freshwater turtle trapping using cathedral and fyke nets • Frog surveys to inform contemporary composition and abundance of frog fauna and guide future watering plans.	Research body or consultants	High
Fish movement throughout mid and lower Loddon River System to confirm effectiveness of fishways, and further refine understanding of required flow magnitudes and timing.	Loddon 4, 5, P1, P2	PF 1 – 3, PF5, PF6	Undertake additional fish movement studies to develop a greater understanding of fish movement in lower Loddon & Pyramid/Box system through Box Creek and Kerang Weir fishways, and along Pyramid Creek.	Research body or consultants	High
An understanding of the habitat requirements and usage by fish, platypus and turtles in Pyramid Creek.	P1, P2	PF 1 – 3, PF5, PF6 SF2 PP1, PP2	Undertake well designed aquatic fauna and habitat surveys in Pyramid Creek, In particular to assess the impact of large wood reintroduction and habitat improvement works.	Research body or consultants	High
The impact of rapid fluctuations in flow rates and water levels during irrigation season on fish behaviour and migration and on bank stability.	Reach 5, P1, P2	PF 1 – 6 SF1, SF2	Undertake a study to monitor the impact that different rates of raising and lowering of water levels have on fish behaviour and bank stability.	Research body or consultants	Medium

Knowledge Gap	Specific reaches	Objective/ Risk	Recommendation	Who	Priority
An accurate understanding of the operational capacity of Pyramid Creek to confirm GMW protocol, which states operational capacity, is 1000 ML/day.	P1, P2, Reach 5	ALL	Commission stream survey, hydraulic modelling & validation to confirm the capacity. If 1000 ML/day is valid this places a constraint on the ability to deliver recommended high environmental flows during irrigation season. There may be a need to consider the feasibility of changing operations of Kerang Lakes to enable top up of lakes with irrigation water prior to Pyramid Creek being run at capacity to deliver environmental high flows.	North Central CMA / GMW	High
Risks					
Comprehensive understanding that recommended flows are accurately delivered, understanding of transmission and operational losses on the Loddon River below Cairn Curran and understanding of flooding constraints (SKM 2006).	Loddon River reaches 1, 2, 3 & 4.	9	Consider installation of the following gauging stations and infrastructure as recommended in the *Goulburn Campaspe Loddon Environmental Flow Delivery Constraints Study* (SKM 2006). • Remote monitoring of all existing gauging stations below Cairn Curran and Tullaroop reservoirs • Monitoring of all diversion sites between Loddon Weir and Kerang Weir to prevent unauthorised diversion of environmental low flow releases • Flow and water level monitoring sites every 20 km along the entire river downstream of Tullaroop and Cairn Curran reservoirs	North Central CMA / Consultants	Medium
Determine the factors influencing native fish abundance e.g. exotic fish pressures, stocking, recreational fishing pressure, cold water, habitat	All	1 4 5	An intensive study into fish population dynamics (size, age classes, qualitative surveys of anglers etc.)	North Central CMA / Research body	High
Quantum of leaf litter loading and extent entrained on river banks over which point a blackwater event is a real risk	All	13	An honours or PhD study to design project	North Central CMA / Research body	Low

Knowledge Gap	Specific reaches	Objective/ Risk	Recommendation	Who	Priority
The degree of impact of surface: groundwater interactions on stream flow and water quality.	Loddon River Reach 1, 2, 3a, and 3b, Serpentine Creek	11	An honours or PhD study to design project	North Central CMA / Research body	Low
The degree to which there is a cold water temperature signature downstream of major storages.	Loddon 1, 2, 3	1	Commission a study into water temperatures downstream of the major Loddon storages and the impact on aquatic life.	North Central CMA / Research body / Consultants	High
Delivery of the full winter / spring fresh flow recommendation for Loddon Reach 3a (900 ML/day) poses a risk of flooding private land if this volume passes below Loddon Weir into Reach 3b which has a channel capacity of 450 ML/day. Further investigation is required to determine the feasibility of diverting this water upstream of Loddon Weir (e.g. into Serpentine and / or Kinypaniel creeks), the channel capacities and delivery mechanisms.	Loddon 3a, 3b	7, 8	Commission detailed investigation into channel capacity and flow management options from reaches 3a and 3 b and Serpentine	North Central CMA / GMW	High
The degree and impact of run-off from townships (e.g. Serpentine and Kerang) on the water quality of Serpentine Creek and the Loddon River	All	10	Investigate urban water pollution from townships and if significant determine mitigation measures.	North Central CMA / Consultant	Medium
The impact of riparian fencing without ongoing management on inappropriate terrestrial vegetation and weed density.	All	PV1, PV2	Vegetation condition assessment in fenced riparian areas	North Central CMA/ Consultant	Medium

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Abbreviations and Acronyms

ANZECC & ARMCANZ	Australian and New Zealand Environment and Conservation Council & Agriculture and Resource Management Council of Australia and New Zealand
AVIRA	Aquatic Value Identification and Risk Assessment
BE	Bulk Entitlement
Bonn	The Convention on the Conservation of Migratory Species of Wild Animals (also known as the Bonn Convention or CMS)
CAMBA	China-Australia Migratory Bird Agreement
CEWH	Commonwealth Environmental Water Holder
CMA	Catchment Management Authority
CSIRO	Commonwealth Industrial and Scientific Research Organisation
DELWP	Department of Environment, Land Water and Planning
DEPI	Department of Environment and Primary Industries (former)
DPI	Department of Primary Industries (former)
DSE	Department of Sustainability and Environment (former)
EFTP	Environmental Flows Technical Panel
EC	Electrical Conductivity
EPBC Act	*Environment Protection and Biodiversity Conservation Act 1999* (Cth)
EPA	Environment Protection Authority
EVC	Ecological Vegetation Class
EWMP	Environmental Water Management Plan
FFG Act	*Flora and Fauna Guarantee Act 1988* (Vic)
GL	Gigalitre (one billion litres)
GIS	Geographical Information System
GMW	Goulburn-Murray Water
HRWS	High Reliability Water Share
ISC	Index of Stream Condition
IVT	Inter Valley Transfer

JAMBA	Japan-Australia Migratory Bird Agreement
LEWAG	Loddon Environmental Water Advisory Group
LRWS	Low Reliability Water Share
LTCE	Long Term Cap Equivalent
Mg/l	Milligrams per litre
MDBA	Murray-Darling Basin Authority (formerly Murray-Darling Basin Commission, MDBC)
ML	Megalitre (one million litres)
ML/d	Megalitres per day
ROKAMBA	Republic of Korea-Australia Migratory Bird Agreement
SCADA	Supervisory Control and Data Acquisition
SEPP (WoV)	State Environmental Protection Policy (Waters of Victoria)
SRA	Sustainable River Audit
SWP	Seasonal Watering Proposal
TLM	The Living Murray Initiative
VEAC	Victorian Environmental Assessment Council
VEFMAP	Victorian Environmental Flows Monitoring and Assessment Program
VEWH	Victorian Environmental Water Holder
VWMS	Victorian Waterway Management Strategy
VWQMN	Victorian Water Quality Monitoring Network
WSPA	Water Supply Protection Area

Appendix 1: Loddon River EWMP Consultation

The North Central CMA assembled separate Community Advisory Groups (CAGs) for the Upper Loddon River, Middle Loddon River and Lower Loddon River, and a Project Advisory Group was established for the Pyramid and Serentine Creek Environmental Flows Assessments. The membership of those groups is presented in Table A 1.

Table A 1: Membership of the Community Advisory Groups for the Upper, Middle and Lower Loddon River and Project Advisory Group Pyramid and Serpentine Creeks.

	Upper Loddon River CAG	Middle Loddon River CAG	Lower Loddon River CAG	Pyramid and Serpentine creeks PAG
Chair	Shane O'Loughlin	Laurie Maxted	Di Bowles	Di Bowles/Laurie Maxted
Community member	Graeme Erbs	Barry Barnes	Ben Hall	Eric Boyd
Community member	Jim Lawson	Murray Haw	Robert Hampton	Elaine Jones
Community member	Cathy McCallum	Paul Haw	Angela Hird	Ben Hall
Community member	Veronica Palmer	Ian Penny	Elaine Jones	Simon Toohey
Community member	Barry Rinaldi	Geoff Leamon	Rob Loats	Chris Harrison
Community member	Alison Teese		Colin Myers	Colin Twigg
Community member			Robert Stevenson	John Nelson
Community member				Rob Loats

The CAGs and PAG provided input during the objectives setting phase of the projects and provided comment on the draft flow recommendations prior to them being finalised.

Community input to the Loddon River environmental flow objectives update

The North Central CMA and Jacobs project team met separately with the three CAGs at the beginning of the project to understand the communities' vision for the Loddon River and the values they would like to see maintained or improved through environmental flows. Andrew Sharpe, Louissa Rogers (NCCMA), Phil Slessar (NCCMA) and Brad Drust (NCCMA) facilitated workshops with CAGs in the Upper Loddon catchment (Newbridge) and Middle Loddon catchment (Durham Ox) on the 28th January 2015; and Andrew Sharpe and Louissa Rogers facilitated a workshop with the CAG for the Lower Loddon catchment (Kerang) on the 29th January 2015 to discuss and document changes to the Loddon River that community members have observed over their lifetime and to understand the environmental values and objectives that the community associate with the river. The main issues and observations raised by each CAG are summarised in Table A 2.

The observations and values identified by the CAG were documented immediately after the community meetings and were discussed by the Environmental Flows Technical Panel (EFTP) during site visits that were conducted on the 3rd and 4th February 2015 and during the FLOWS objectives setting workshop that was held at Huntly on 5th and 6th February. The FLOWS objectives workshop was facilitated by Jacobs and was attended by members of the EFTP and the Project Steering Committee. The community observations provided important context to support the field observations of the EFTP and the technical literature review that each member of the EFTP conducted. After the FLOWS objectives setting workshop, Jacobs prepared draft Flows Objective Reports for the Upper Loddon River, Middle Loddon River and Lower Loddon River. The NCCMA distributed those draft reports to the CAG members for comment. Those comments were used to finalise the Flows Objectives reports for each part of the catchment and to set the final environmental flow objectives for each reach.

Table A 2: Summary of issues raised by CAG members during preliminary community consultation meetings.

Issues raised by Community Advisory Group members
Upper Loddon River
• Sand has infilled many of the deep pools that used to characterise the upper reaches of the Loddon River, particularly in Tullaroop Creek near Carisbrook. This sand has probably come from historical mining activities higher in the catchment and erosion in sub-catchments. The rate of sand movement is not known. The sand combined with willows has caused the river channel to become much wider and flatter than it was and therefore now provides fewer habitats for fish, platypus and other biota. • The river historically had moderate floods in most winters, but there have been very few winter floods in the last 20 years and the recent large floods have been in summer. • Anglers used to frequently catch large numbers of a variety of species including Redfin, Trout, Golden Perch and Murray Cod. River Blackfish were also caught in Tullaroop Creek. Very few fish have been caught in the last 20 years, although there have been better catches since the 2011 floods. Angling is important for the community. Anglers would like to be able to go fishing and catch something they can eat; they don't necessarily mind what species it is. • Carp appear to have moved further upstream in recent years. They are probably less abundant downstream of Laancecoorie Reservoir compared to 20 years ago, but are becoming more abundant in Tullaroop Creek. • Platypus used to be abundant in the Upper Loddon River, particularly in Tullaroop Creek. Rinaldi used to regularly see two families near his property at Carisbrook. Adult platypus were observed swimming in flood waters in 2011, but the community thinks that numbers have dropped since that flood and sightings are now very rare. • The community would like the river to have good water quality. By that they mean that it should be relatively clear (it was very clear historically, but has become much more turbid since Carp arrived), have low salt concentrations and no Blue Green Algal blooms. During the drought there were frequent algal blooms near Carisbrook and water in Tullaroop Creek was very salty. • Many landowners have fenced their riparian zones and some areas have been actively replanted. There is some concern that these efforts have not been very successful. In some places the fences and planted wattles were destroyed by the floods. Some community members are concerned that the large number of trees that have fallen into the river have reduced the hydraulic capacity of the river channel and therefore increased the risk that land and towns such as Carisbrook will flood. Community members discussed the need to use light grazing to control weeds and flood and fire risks associated with fenced off riparian zones. • During the drought, *Phragmites* and *Typha* choked much of the river channel and reduced its hydraulic capacity. Much of that was removed during the floods and is starting to grow back at the margins of the channel. • River Red Gum were originally only on the banks now they are growing further on the floodplain in fenced off areas, which suggests that grazing by livestock has played a large part in restricting the recruitment of these trees. • The Loddon Stressed Rivers Project has helped fence approximately 600 Km of river frontage in the Loddon River catchment. Approximately half of that has been on the Loddon River and the rest has been in tributaries or distributary channels. Approximately 150 km of river frontage doesn't need fencing because it is in other reserves, but there is still approximately 150 km of river frontage that still requires fencing to exclude livestock.

Issues raised by Community Advisory Group members
Middle Loddon River
• Community members would like to see flow in the river all year round and good water quality. The community is particularly aware of blackwater events and would like to prevent them. There was a discussion about the need for variable water levels to prevent notching of the banks and that seasonal fluctuations are important for biological processes. The NCCMA probably needs to do more to inform the community about the importance of seasonal flow patterns and wetting and drying on the bank to drive ecological productivity. • Paul Haw provided a detailed history of changes to this part of the Loddon River. Before the irrigation system was developed, the Middle Loddon River used to dry in most years but also had regular medium sized floods. Local community members recall the river flooding in most winters until the mid-1990s. The 2011 flood was the largest in memory, but also occurred in summer, which was not good. • There are relatively few deep pools in the reach and therefore not likely to be much refuge habitat for fish and other biota during very low flow or cease-to-flow events. The main exception is a section of Twelve Mile Creek just downstream of the regulator that still has some reasonable pools, which have formed around fallen River Red Gums. It is accepted that constant flows have contributed to the infilling of pools and flattening of the streambed and there is a willingness to provide some larger flows to scour and maintain pools • The channel capacity declines markedly through the Middle Loddon River as flood-runners carry water from the main channel onto the floodplain. There is an acceptance by some landowners to allow environmental water to inundate some private property in the reach as long as the floods occur in winter or early spring and are not too large. • Community members agreed that Twelve Mile Creek is the natural flow path for the Loddon River past Canary Island and has greater environmental values than the West Branch of Loddon River that runs down the west side of Canary Island. Moreover, they are happy that the majority of low flows are directed down Twelve Mile Creek instead of the West Branch of the Loddon River. There is a proposal to repair the Twelve Mile Creek regulator and fix a sill at a low level (approximately equivalent to leaving only 2-3 boards in the bottom of the current structure). This repaired structure would allow most of the low flow to pass down Twelve Mile Creek, with a small volume still watering the West Branch of the Loddon River. • River Blackfish were historically caught in the Middle Loddon River, but were displaced by exotic species such as Redfin and Carp. All fish were lost from the Middle Loddon River during the drought. • Community members commented that Carp had caused many problems in the Loddon River including damage to instream and fringing vegetation through direct foraging and associated increased turbidity. In removing instream vegetation they have also reduced habitat for native fish and frogs. The loss of frogs has resulted in a substantial loss of snakes that would have naturally fed on the frogs.

Issues raised by Community Advisory Group members
Lower Loddon River
• High priority is to maintain and improve a diverse native fish community in the river. The community is particularly interested in improving the abundance of large-bodied angling species, but know that it is also important to provide flows, habitat and food for small-bodied native fish. • The Lower Loddon River has silted up considerably over the years due to the operation of Pyramid Creek as an irrigation carrier and poor land management that has contributed to local bank erosion. This silt has filled virtually all the deep holes in the river and created a silt bed that has been colonised by *Typha* and Phragmites, which has choked the channel in places. • The community would like permanent flow in the reach with appropriate flow variability to prevent bank erosion and to facilitate required ecological processes. They did not want environmental flows to exceed the capacity of the channel, because they are concerned about flooding and do not see any great value in watering the floodplain given it doesn't have any wetlands. • Community members spoke about the large amount of work that has been done to fence off riparian zones, but also highlighted inconsistencies in rules about grazing between Parks Victoria (i.e. no grazing) and DELWP (i.e. some controlled grazing to manage risks) and inconsistencies in the adherence to such rules. Many community members that have river frontage in the lower Loddon River commented on potential weed problems in areas that had been fenced and excessive lignum growth that may represent a fire risk and flood risk. The community would like more information about what is a reasonable target for riparian zone management, what the risks are and how they should manage weeds, and excessive native plant growth. • Stormwater run-off from Kerang is a risk to water quality in the reach. • Other issues in the reach include pest species such as Carp, foxes and rabbits. • Community members spoke about the need for the local urban community to value the Loddon River more and that more needed to be done to educate them about its ecological and recreational values so they will use it and look after it. • The community raised the issue that Sheepwash Creek was the natural continuation of the Loddon River and that some work should be done to investigate environmental values and flow requirements for that system. The NCCMA took that comment on notice and may look at it through a separate project. • Some community members said they could catch cod from the river with their hands when they were kids, they also caught catfish. Native fish became less abundant when carp were introduced. • Community members have seen more Golden Perch in the Lower Loddon River in recent years than at any time since the 1980s. • During the drought there were some native fish in remnant pools, but community members think since the floods there are now more carp. • Used to be fish kills associated with blackwater events. These were relatively common, and killed many different types of native fish. That is bad on one level, but it also demonstrated that there were or still are lots of different native fish species in the reach. • Historically the Lower Loddon River had lots of turtles, but these have become rarer. The community attribute that to egg predation by foxes. • The whole reach of the Lower Loddon River was desnagged in the 1970s, since then some trees have fallen into the river and they now provide some habitat for fish and other biota, but there are not as many snags as other parts of the Loddon River.

Community input to the revised Loddon River environmental flow recommendations

The EFTP and Project Steering Committee conducted a FLOWs workshop at the Jacobs office on 26-27th February 2015 to revise the environmental flow recommendations for each reach of the Loddon River. Jacobs prepared a draft report that described the current condition of the Loddon River, the environmental flow objectives for each reach of the river and the environmental flows that needed to be delivered to help meet those objectives.

Andrew Sharpe and Louissa Rogers met with community members in the Upper Loddon, MidLoddon and Lower Loddon System to present the draft revised environmental flow recommendations for each reach, to answer any questions and seek community feedback. The North Central CMA provided all CAG members with a copy of the draft environmental flows report after the meeting and invited CAG members to provide specific feedback. That feedback was used to finalise the environmental flow recommendations.

Values and threats in Serpentine Creek identified by the Project Advisory Group.

Members of the Project Advisory Group who attended the project meeting at Kerang on 17th April 2014 were invited to describe how the Serpentine Creek has changed over time, the current and historical values associated with the Creek, environmental threats and what improvements they would like to see made to the creek. Responses by PAG members indicate the following:

- Serpentine Creek is valued for the significant flora and fauna that it supports, recreation activities such as fishing and amenity, cultural heritage and as a supplier of irrigation water;
- Other than the altered flow regime, the main threats to Serpentine Creek are pollution from urban run-off, uncontrolled stock access and the presence of pest species such as Carp;
- Suggested improvement actions include flow management to increase flow in those sections of the creek that currently have very little flow and to meet the water requirements of the River Red Gum Swamp in Nine Mile Creek approximately 1.5 kilometres downstream of Nine Mile Creek regulator, fencing to exclude livestock, and measures to reduce pollution from urban and rural run-off.

More details of the information provided by the members of the PAG are presented in **Error! Reference source not found.**. This information has been used to help develop environmental water objectives for Serpentine Creek.

Table A 3: Serpentine Creek environmental values, observed changes, key threats and improvement actions. This information was collated through discussions with the PAG on the 17 April 2014.

Values	• Fish populations (Blackfish, Murray Cod and Redfin). Other significant fauna include platypus, birds (Brolgas), goanna's and water rats. • Recreation (fishing, shooting, scouts, bird watching). • Red Gum Woodland along Nine Mile, individual trees estimated to be 300 years old. Pennyroyal Creek known as the largest Lignum Swamp. • Cultural heritage (medicine trees and middens). • Irrigation supply for farming community.
How has the creek changed over time	• Historically was known as a reliable source of water for early settlers, considered more reliable than Loddon with people coming from far to collect water • Deterioration in condition of creek, as given by examples such as in the past being able to dig for worms in the bank but there being no worms now, used to be Curlows but don't see them now. • Perception that flows have been reduced since the drought, particularly within the vicinity of Serpentine Town. • Modernisation of the irrigation system has reduced incidental inflows to sections of Serpentine Creek. • Has been some clearing of Lignum to create a flow path along Pennyroyal (started at end of Serpentine Creek, this occurred 6-8 years ago) • Progressive fencing has improved the condition of the waterways
Key threats	• Water quality, urban water pollution from Serpentine Town and concerns about salinity levels along Nine Mile Creek. • Growth of Cumbungi and its spread along river channels. This has choked some sections but floods have also been effective in scouring out areas. Willow trees also noted. • Illegal fishing and pest species such as Carp. • People do not appreciate the values of the creek and allow unrestricted stock access.
Improvement actions	• Increased flow in different sections of the Serpentine Creek, in particular the upper parts through Serpentine town and the Red Gum Woodland along Nine Mile Creek. • Fencing of creek, maintenance of fenced areas and policing to keep stock out of waterways. • Constant flow of water to keep creek in good condition and meet irrigation requirements (cease-to-flow not desired). • Management actions that will lead to healthier native small and large bodied fish populations (i.e. improve water quality and habitat through fencing and control of stock, treat point sources)

Values and threats in Pyramid Creek identified by the Project Advisory Group.

Members of the Project Advisory Group who attended the project meeting at Kerang on 17th April 2014 were invited to describe how Pyramid Creek has changed over time, the current and historical values associated with the creek, environmental threats and what improvements they would like to see made to the creek. Responses by PAG members indicate the following:

- Pyramid Creek is valued for the significant flora and fauna (especially native fish) it supports, recreation activities and cultural heritage.
- Key threats are the high range and fluctuation in flows associated with its use as a delivery channel for irrigation and domestic water, uncontrolled stock access, pests such as Carp, illegal fishing and absentee landowners who don't maintain fencing and protect vegetation along the banks.
- Suggested improvement actions include fencing and revegetation, reintroduction of LWD and altering flows at different times of the year, especially for Murray Cod and Golden and Silver Perch.

More details of the information provided by the members of the PAG are presented in. This information has been used to help develop environmental water objectives for Pyramid Creek.

Table A 4: Pyramid Creek environmental values, observed changes, key threats and improvement actions. This information was collated through discussions with the PAG on the 17 April 2014.

Values	• Fish populations (Murray Cod, Golden Perch and Redfin*) and fish passage. Other significant fauna include water rats, carpet pythons, goannas, black swamp wallabies, waterbirds (Bush Stone Curlews, Brolgas), sea eagles and wedge- tailed eagles. • Recreation (fishing, bird watching). • High quality vegetation in some sections (Black Box and River Red Gum), vegetation recovery has improved as a result of fencing and control of stock. • Cultural heritage (scar trees and middens).
How has the creek changed over time	• Prior to dredging the creek was characterised by much wider pools and swamps that were connected during high flows. • Dredging lowered the original bed by four feet, and cut through sand layers. Hird Swamp and Johnson Swamp are now disconnected from the creek. • Spoil dredged from the channel and piled on banks killed riparian trees. Major changes in waterbirds following dredging with many duck species dropping off in numbers and low lying wetlands lost. • Water now backs up approximately 6 km from Kerang Weir. • The creek has high flow throughout the irrigation season and very low flow during winter. These flow patterns are the reverse of the natural flow regime.
Key threats	• Pyramid Creek experiences a high range in flows, it is a conduit of Mid-Murray Storages irrigation system and is run as a working river. The large fluctuations in flow erode the bare banks and this is evident as collapsed banks, fences that have fallen into the creek and exposed concrete drains. Erosion is more noticeable on bends. • The first flush of water from Kow Swamp in spring is poor quality and very turbid. • Uncontrolled stock access, degrades the banks and delivers large amounts of silt to the waterway. Unrestricted stock access varies along the system. Twenty cows died last year, they get in channel and can't get out. Some farms have grazing rights to the edge of the channel. • Weeds and pests such as Box Thorn, rabbits/foxes. Aquatic weeds (parrots feather). • Key threats to fish are European Carp and illegal fishing. Drum nets capture fish and turtles. • People do not appreciate the values of the creek, there are also numerous absentee landowners which means that stock access may go unnoticed or weed control and revegetation programs are not maintained.
Improvement actions	• Fencing and revegetation along the entire length of the waterway (direct seeding or planting). • Improve fish habitat through reintroduction of LWD and get stock off stream. Improve fish requirements by altering flows at different times of the year, especially for Murray Cod and Golden Perch. • Greater engagement with community and school children. • Control pests such as Carp. • Rehabilitation of creek, create shelves and benches.

* Redfin is an exotic species, but is valued by the community for angling.

Appendix 2: Land tenure

Table 30: Land status of riparian frontage on the Loddon system e-flow reaches[12]

Reach number	Environmental flows reach	Licenced Crown frontage	Other public land	Private land frontage
LR1	Loddon River below Cairn Curran	7%	22%	71%
LR2	Tullaroop Creek below Tullaroop Reservoir	3%	26%	71%
LR3a	Loddon River, Laanecoorie to Serpentine Weir	41%	10%	49%
LR3b	Loddon River, Serpentine Weir to Loddon Weir	17%	0%	83%
LR4a	Loddon River, Loddon Weir to Twelve Mile Creek	71%	7%	22%
LR4b	Twelve Mile Creek	0%	0 %	100 %
LR4c	Loddon River, parallel to Twelve Mile Creek	94%	6%	0%
LR4d	Loddon River, Twelve Mile Creek to Kerang Weir	53%	39%	8%
LR5	Loddon River, Kerang Weir to Little Murray River	85%	13%	2%
S1	Serpentine Creek, Weir to Waranga Western Channel	35%	6%	59%
S2	Serpentine Creek, Waranga Channel to No 2 Channel	0%	0%	100%
S3	Serpentine Creek, No 2 Channel to Channel 7/10/1	18%	3%	79%
S4	Serpentine Creek, Channel 7/10/1 to No 12 Channel	8%	42%	50%
S5	Nine Mile Creek	0%	0%	100%
S6	Pennyroyal Creek	5%	0%	95%
P1	Pyramid Creek, Kow Swamp to Hird Swamp	14%	83%	3%
P2	Pyramid Creek, Hird Swamp to Kerang Weir	28%	71%	1%
	Total	41%	20%	39%

[12] Land status along the waterways considered in this EWMP has been analysed according to its status as freehold or private frontage, licensed Crown frontage or other public land. This information is presented as a percentage of total frontage along both sides of the waterway i.e. a river length of 10 km will equate to 20 km of frontage.

Appendix 3: Riparian fencing

Table A3 1: Riparian fencing on Loddon system e-flow reaches[13]

Reach number	Environmental flows reach	Frontage fenced	Frontage otherwise protected	Frontage not fenced
LR1	Loddon River below Cairn Curran	26%	14%	60%
LR2	Tullaroop Creek below Tullaroop Reservoir	33%	13%	54%
LR3a	Loddon River, Laanecoorie to Serpentine Weir	38%	4%	58%
LR3b	Loddon River, Serpentine Weir to Loddon Weir	62%	0%	38%
LR4a	Loddon River, Loddon Weir to Twelve Mile Creek	93%	0%	7%
LR4b	Twelve Mile Creek	0%	0%	100%
LR4c	Loddon River, parallel to Twelve Mile Creek	68%	0%	32%
LR4d	Loddon River, Twelve Mile Creek to Kerang Weir	73%	12%	15%
LR5	Loddon River, Kerang Weir to Little Murray River	27%	0%	73%
S1	Serpentine Creek, Weir to Waranga Western Channel	46%	0%	54%
S2	Serpentine Creek, Waranga Channel to No 2 Channel	12%	0%	88%
S3	Serpentine Creek, No 2 Channel to Channel 7/10/1	15%	0%	85%
S4	Serpentine Creek, Channel 7/10/1 to No 12 Channel	8%	0%	92%
S5	Nine Mile Creek	0%	0%	100%
S6	Pennyroyal Creek	12%	0%	88%
P1	Pyramid Creek, Kow Swamp to Hird Swamp	27%	0%	73%
P2	Pyramid Creek, Hird Swamp to Kerang Weir	0%	9%	91%
	Total	**41%**	**4%**	**55%**

[13] In different sections of the waterway there may be fencing on the left bank, right bank, both banks or neither bank of the waterway. **Error! Reference source not found.** presents this information based on current data in the North Central CMA Geographic Information System; this is presented as a percentage of total frontage along both sides of the waterway.

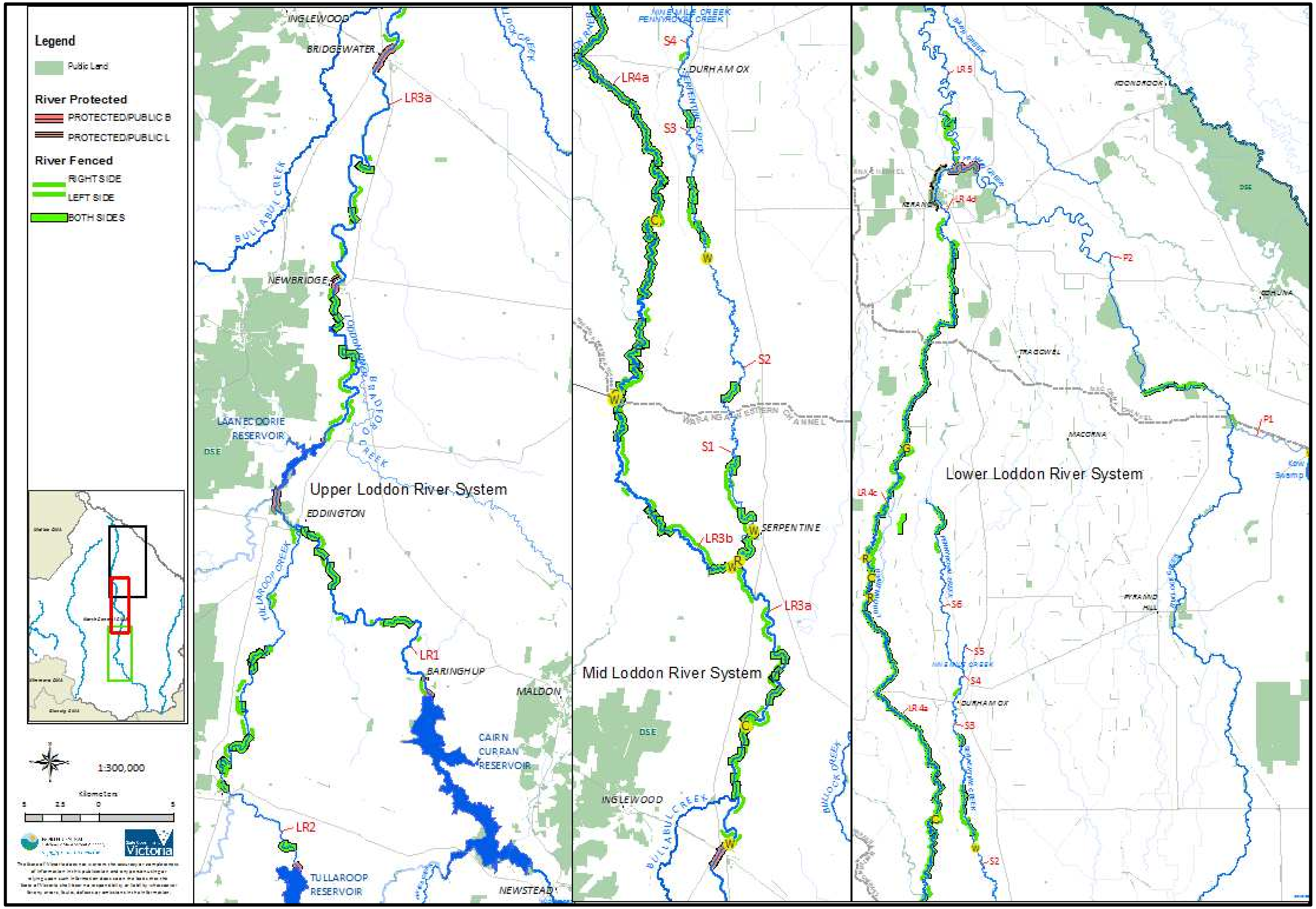

Figure A3 1: Protected public and fenced private riparian land along the Loddon River System (Source: North Central CMA 2015a)

Appendix 4: Loddon River environmental watering history (2004 -14)

Flow component	2004/05	2005/06	2006/07	2007/08	2008/09	2009/10	2010/11	2011-12	2012-13	2013-14	2014-15
Reach 1											
Summer passing flows	Met	Partially met	Partially met	Partially met	Met	Partially met	Met	Partially met	Met	Partially met	Not met
Summer fresh	Met	Met	Met	Met	Met	Met	Met	Partially met	Partially met	Partially met	Met
Winter passing flows	Partially met	Not met	Not met	Not met	Not met	Not met	Not met	Met	Met	Met	Met
Early winter fresh	Not met	Not met	Not met	Not met	Not met	Not met	Not met	Not met	Partially met	Not met	Partially met
Bank full	Not met	Not met	Not met	Not met	Not met	Not met	Met	Not met	Partially met	Not met	Not met
Reach 2											
Minimum all year	Partially met	Not met	Not met	Not met	Not met	Not met	Partially met	Partially met	Partially met	Met	Partially met
Fresh	Met	Met	Not met	Not met	Not met	Not met	Met	Partially met	Met	Met	Met
Early winter fresh	Not met	Not met	Not met	Not met	Not met	Not met	Not met	Partially met	Met	Not met	Not met
High flow	Not met	Not met	Not met	Not met	Not met	Not met	Met	Met	Met	Not met	Not met
Reach 3a											
Summer–Autumn min	Partially met	Met	Met	Partially met	Partially met	Partially met	Met	Partially met	Partially met	Not met	Not met
Summer fresh	Met	Met	Not met	Not met	Not met	Not met	Met	Partially met	Partially met	Met	Met
Winter minimum	Partially met	Not met	Not met	Not met	Not met	Not met	Met	Partially met	Partially met	Partially met	Not met
Spring fresh	Not met	Not met	Not met	Not met	Not met	Not met	Met	Partially met	Partially met	Not met	Partially met
Reach 3b											
Summer minimum	Not met	Met	Not met	Not met	Not met	Not met	Met	Partially met	Met	Partially met	Partially met
Summer fresh	Met	Not met	Not met	Not met	Not met	Not met	Met	Met	Met	Met	Partially met
Winter minimum	Not met	Not met	Not met	Not met	Not met	Not met	Partially met	Partially met	Met	Partially met	Partially met
Winter – Spring fresh	Not met	Not met	Not met	Not met	Not met	Not met	Met	Met	Met	Met	Not met
Bank full	Not met	Not met	Not met	Not met	Not met	Not met	Met	Not met	Partially met	Not met	Not met
Reach 4											
Summer minimum	Not met	Not met	Not met	Not met	Not met	Not met	Met	Met	Met	Met	Met
Summer fresh	Not met	Not met	Not met	Not met	Not met	Not met	Met	Partially met	Met	Met	Met
Winter minimum	Not met	Not met	Not met	Not met	Not met	Not met	Partially met	Met	Met	Met	Met
Winter – Spring fresh	Not met	Not met	Not met	Not met	Not met	Not met	Met	Met	Met	Partially met	Partially met
Bank full	Not met	Not met	Not met	Not met	Not met	Not met	Met	Partially met	Met	Not met	Not met
Reach 5											
Summer minimum	Not met	Not met	Met	Partially met	Not met	Not met	Not met	Not met	Partially met	Not met	Partially met
Summer fresh	Not met	Not met	Met	Partially met	Not met	Partially met	Partially met	Not met	Partially met	Partially met	Partially met
Winter minimum	Partially met	Met	Met	Partially met	Not met	Not met	Not met	Not met	Not met	Partially met	Partially met
Aug-Sep high	Partially met	Partially met	Not met	Not met	Not met	Not met	Met	Met	Partially met	Met	Not met
Oct-Nov high	Met	Not met	Not met	Not met	Not met	Not met	Met	Partially met	Met	Partially met	Not met
Spring bank full	Not met	Not met	Not met	Not met	Not met	Not met	Met	Not met	Not met	Not met	Not met

(red)	Flow component not met	(orange)	Flow component partially met	(green)	Flow component met

Appendix 5: Species List

Source: DELWP 2015a; Jacobs 2014f

Species that are in bold print are significant; * listed under FFG Lowland Riverine Fish Community of the Murray-Darling Basin

Table A5 1: Fauna species list for the Loddon River System

Reach	Common name	Scientific name	Date of last record
Native fish			
LR1	**Freshwater Catfish***	***Tandanus tandanus***	**2004**
LR1	**Golden Perch***	***Macquaria ambigua***	**1995**
LR1	**Macquarie Perch***	***Macquaria australasica***	**1970**
LR1	**Murray Cod***	***Maccullochella peelii***	**1994**
LR2	Australian Smelt*	*Retropinna semoni*	2014
LR2	Flat-headed Gudgeon*	*Philypnodon grandiceps*	2014
LR2	**Golden Perch***	***Macquaria ambigua***	**2014**
LR2	**Macquarie Perch***	***Macquaria australasica***	**1930**
LR2	**Mountain Galaxias**	***Galaxias olidus***	**2011**
LR2	**Murray Cod***	***Maccullochella peelii***	**1935**
LR2	Obscure Galaxias	*Galaxias sp. 1*	2014
LR2	River Blackfish*	*Gadopsis marmoratus*	2014
LR3a	Australian Smelt*	*Retropinna semoni*	2014
LR3a	Carp Gudgeon	*Hypseleotris spp.*	2014
LR3a	Dwarf Flat-headed Gudgeon	*Philypnodon macrostomus*	2011
LR3a	Flat-headed Gudgeon*	*Philypnodon grandiceps*	2014
LR3a	**Golden Perch***	***Macquaria ambigua***	**2014**
LR3a	**Macquarie Perch***	***Macquaria australasica***	**1995**
LR3a	**Murray Cod***	***Maccullochella peelii***	**2014**
LR3a	**Murray-Darling Rainbowfish***	***Melanotaenia fluviatilis***	**2014**
LR3b	Australian Smelt*	*Retropinna semoni*	2014
LR3b	Carp Gudgeon	*Hypseleotris spp*	2014
LR3b	Dwarf Flat-headed Gudgeon	*Philypnodon macrostomus*	2014
LR3b	Flat-headed Gudgeon*	*Philypnodon grandiceps*	2014
LR3b	**Golden Perch***	***Macquaria ambigua***	**2014**
LR3b	**Murray Cod***	***Maccullochella peelii***	**2012**
LR3b	**Murray-Darling Rainbowfish***	***Melanotaenia fluviatilis***	**2014**
LR3b	Western Carp Gudgeon*	*Hypseleotris klunzingeri*	2012
LR4a	Australian Smelt*	*Retropinna semoni*	2014
LR4a	Carp Gudgeon	*Hypseleotris spp.*	2014
LR4a	Flat-headed Gudgeon*	*Philypnodon grandiceps*	2014
LR4a	**Golden Perch***	***Macquaria ambigua***	**2012**
LR4a	**Murray-Darling Rainbowfish***	***Melanotaenia fluviatilis***	**2014**
LR4a	Western Carp Gudgeon*	*Hypseleotris klunzingeri*	2012
LR4c	Carp Gudgeon	*Hypseleotris spp.*	2012
LR4c	Western Carp Gudgeon*	*Hypseleotris klunzingeri*	2012
LR4d	Australian Smelt*	*Retropinna semoni*	2012
LR4d	Bony Bream*	*Nematalosa erebi*	2014
LR4d	Carp Gudgeon	*Hypseleotris spp.*	2014
LR4d	Flat-headed Gudgeon*	*Philypnodon grandiceps*	2010
LR4d	**Golden Perch***	***Macquaria ambigua***	**2014**

Reach	Common name	Scientific name	Date of last record
LR4d	**Murray-Darling Rainbowfish***	***Melanotaenia fluviatilis***	**2012**
LR4d	**Silver Perch***	***Bidyanus bidyanus***	**2012**
LR4d	Western Carp Gudgeon*	*Hypseleotris klunzingeri*	2012
LR5	Australian Smelt*	*Retropinna semoni*	2014
LR5	Bony Bream*	*Nematalosa erebi*	2014
LR5	Carp Gudgeon	*Hypseleotris spp.*	2014
LR5	Flat-headed Gudgeon*	*Philypnodon grandiceps*	2014
LR5	**Golden Perch***	***Macquaria ambigua***	**2014**
LR5	**Murray Cod***	***Maccullochella peelii***	**2014**
LR5	**Murray-Darling Rainbowfish***	***Melanotaenia fluviatilis***	**2014**
LR5	**Unspecked Hardyhead***	***Craterocephalus fulvus***	**2014**
Serp	Australian Smelt*	*Retropinna semoni*	2009
Serp	Carp Gudgeon	*Hypseleotris spp.*	2012
Serp	Flathead Gudgeon*	*Philypnodon grandiceps*	2013
Serp	**Murray Cod**	***Maccullochella peelii***	**2014**
Serp	River Blackfish*	*Gadopsis marmoratus*	2010
Pyramid	Carp Gudgeon	*Hypseleotris spp.*	2014
Pyramid	Flathead Gudgeon*	*Philypnodon grandiceps*	2010
Pyramid	Bony Bream*	*Nematalosa erebi*	2014
Pyramid	**Golden Perch**	***Macquaria ambigua***	**2014**
Pyramid	**Murray Cod***	***Maccullochella peelii***	**2014**
Pyramid	**Silver Perch***	***Bidyanus bidyanus***	**2011**
Exotic Fish			
LR1	Brown Trout	*Salmo trutta*	1993
LR1	Carp	*Cyprinus carpio*	1990
LR1	Goldfish	*Carassius auratus*	1993
LR1	Rainbow Trout	*Oncorhynchus mykiss*	1990
LR1	Redfin	*Perca fluviatilis*	1993
LR2	Brown Trout	*Salmo trutta*	2011
LR2	Carp	*Cyprinus carpio*	2014
LR2	Gambusia	*Gambusia holbrooki*	2014
LR2	Goldfish	*Carassius auratus*	2014
LR2	Rainbow Trout	*Oncorhynchus mykiss*	2011
LR2	Redfin	*Perca fluviatilis*	2014
LR2	Tench	*Tinca tinca*	2014
LR3a	Carp	*Cyprinus carpio*	2014
LR3a	Gambusia	*Gambusia holbrooki*	2014
LR3a	Goldfish	*Carassius auratus*	2014
LR3a	Oriental Weatherloach	*Misgurnus anguillicaudatus*	1994
LR3a	Redfin	*Perca fluviatilis*	2014
LR3b	Carp	*Cyprinus carpio*	2014
LR3b	Gambusia	*Gambusia holbrooki*	2014
LR3b	Goldfish	*Carassius auratus*	2014
LR3b	Redfin	*Perca fluviatilis*	2011
LR4a	Carp	*Cyprinus carpio*	2014
LR4a	Gambusia	*Gambusia holbrooki*	2014

Reach	Common name	Scientific name	Date of last record
LR4a	Goldfish	*Carassius auratus*	2014
LR4a	Oriental Weatherloach	*Misgurnus anguillicaudatus*	2012
LR4a	Redfin	*Perca fluviatilis*	2012
LR4c	Carp	*Cyprinus carpio*	2014
LR4c	Gambusia	*Gambusia holbrooki*	2014
LR4c	Goldfish	*Carassius auratus*	2014
LR4c	Oriental Weatherloach	*Misgurnus anguillicaudatus*	2014
LR4d	Carp	*Cyprinus carpio*	2014
LR4d	Gambusia	*Gambusia holbrooki*	2014
LR4d	Goldfish	*Carassius auratus*	2014
LR4d	Oriental Weatherloach	*Misgurnus anguillicaudatus*	2012
LR4d	Redfin	*Perca fluviatilis*	2014
LR5	Carp	*Cyprinus carpio*	2014
LR5	Gambusia	*Gambusia holbrooki*	2014
LR5	Goldfish	*Carassius auratus*	2014
LR5	Redfin	*Perca fluviatilis*	2014
Serp	Carp	*Cyprinus carpio*	2013
Serp	Gambusia	*Gambusia holbrooki*	1989
Serp	Goldfish	*Carassius auratus*	2012
Serp	Redfin Perch	*Perca fluviatilis*	2010
Pyramid	Carp	*Cyprinus carpio*	2014
Pyramid	Gambusia	*Gambusia holbrooki*	2011
Pyramid	Goldfish	*Carassius auratus*	2014
Pyramid	Redfin Perch	*Perca fluviatilis*	2012
Waterbirds			
LR1	Australian Pelican	*Pelecanus conspicillatus*	2000
LR1	Australian Shelduck	*Tadorna tadornoides*	1999
LR1	Australian White Ibis	*Threskiornis molucca*	2000
LR1	Australian Wood Duck	*Chenonetta jubata*	2000
LR1	Black Swan	*Cygnus atratus*	2000
LR1	Clamorous Reed Warbler	*Acrocephalus australis*	2000
LR1	Darter	*Anhinga novaehollandiae*	2000
LR1	Dusky Moorhen	*Gallinula tenebrosa*	2001
LR1	**Eastern Great Egret**	***Ardea modesta***	**2000**
LR1	Great Cormorant	*Phalacrocorax carbo*	2000
LR1	Grey Teal	*Anas gracilis*	2000
LR1	Little Black Cormorant	*Phalacrocorax sulcirostris*	2000
LR1	Little Pied Cormorant	*Microcarbo melanoleucos*	2001
LR1	Masked Lapwing	*Vanellus miles*	2000
LR1	**Nankeen Night Heron**	***Nycticorax caledonicus hillii***	**1999**
LR1	Pacific Black Duck	*Anas superciliosa*	2000
LR1	Sacred Kingfisher	*Todiramphus sanctus*	2000
LR1	White-faced Heron	*Egretta novaehollandiae*	2000
LR1	Yellow-billed Spoonbill	*Platalea flavipes*	2000
LR2	Australian White Ibis	*Threskiornis molucca*	1999

Reach	Common name	Scientific name	Date of last record
LR2	Australian Wood Duck	*Chenonetta jubata*	2000
LR2	Clamorous Reed Warbler	*Acrocephalus australis*	1999
LR2	Dusky Moorhen	*Gallinula tenebrosa*	2000
LR2	Little Pied Cormorant	*Microcarbo melanoleucos*	2001
LR2	Pacific Black Duck	*Anas superciliosa*	2001
LR2	Sacred Kingfisher	*Todiramphus sanctus*	2001
LR2	White-faced Heron	*Egretta novaehollandiae*	2001
LR3a	Australasian Grebe	*Tachybaptus novaehollandiae*	1999
LR3a	Australian Shelduck	*Tadorna tadornoides*	2000
LR3a	Australian White Ibis	*Threskiornis molucca*	2000
LR3a	Australian Wood Duck	*Chenonetta jubata*	2001
LR3a	Clamorous Reed Warbler	*Acrocephalus australis*	1999
LR3a	Clamorous Reed Warbler	*Acrocephalus australis*	1998
LR3a	Darter	*Anhinga novaehollandiae*	1998
LR3a	Dusky Moorhen	*Gallinula tenebrosa*	2001
LR3a	Dusky Moorhen	*Gallinula tenebrosa*	2001
LR3a	Eurasian Coot	*Fulica atra*	2000
LR3a	Great Cormorant	*Phalacrocorax carbo*	2001
LR3a	Grey Teal	*Anas gracilis*	2001
LR3a	Little Black Cormorant	*Phalacrocorax sulcirostris*	1999
LR3a	Little Pied Cormorant	*Microcarbo melanoleucos*	2001
LR3a	Masked Lapwing	*Vanellus miles*	2001
LR3a	**Nankeen Night Heron**	***Nycticorax caledonicus hillii***	**2001**
LR3a	Pacific Black Duck	*Anas superciliosa*	2001
LR3a	**Rainbow Bee-eater**	***Merops ornatus***	**1998**
LR3a	Sacred Kingfisher	*Todiramphus sanctus*	2001
LR3a	White-faced Heron	*Egretta novaehollandiae*	2001
LR3a	White-necked Heron	*Ardea pacifica*	2000
LR3a	Yellow-billed Spoonbill	*Platalea flavipes*	2000
LR3b	Australian Shelduck	*Tadorna tadornoides*	1978
LR3b	Australian Wood Duck	*Chenonetta jubata*	2000
LR3b	Banded Lapwing	*Vanellus tricolor*	1978
LR3b	Black Swan	*Cygnus atratus*	2000
LR3b	Clamorous Reed Warbler	*Acrocephalus australis*	1980
LR3b	Dusky Moorhen	*Gallinula tenebrosa*	1980
LR3b	Grey Teal	*Anas gracilis*	1979
LR3b	Masked Lapwing	*Vanellus miles*	1979
LR3b	Pacific Black Duck	*Anas superciliosa*	1979
LR3b	Rainbow Bee-eater	*Merops ornatus*	1980
LR3b	**Royal Spoonbill**	***Platalea regia***	**1978**
LR3b	Sacred Kingfisher	*Todiramphus sanctus*	1979
LR3b	White-faced Heron	*Egretta novaehollandiae*	1979
LR3b	White-necked Heron	*Ardea pacifica*	1979
LR3b	Yellow-billed Spoonbill	*Platalea flavipes*	1978

Reach	Common name	Scientific name	Date of last record
LR4a	Australian White Ibis	*Threskiornis molucca*	2001
LR4a	Australian Wood Duck	*Chenonetta jubata*	2012
LR4a	Grey Teal	*Anas gracilis*	2001
LR4a	**Intermediate Egret**	***Ardea intermedia***	**2001**
LR4a	Masked Lapwing	*Vanellus miles*	2001
LR4a	Pacific Black Duck	*Anas superciliosa*	2012
LR4a	Sacred Kingfisher	*Todiramphus sanctus*	2001
LR4a	White-faced Heron	*Egretta novaehollandiae*	2012
LR4a	White-faced Heron	*Egretta novaehollandiae*	2001
LR4a	Yellow-billed Spoonbill	*Platalea flavipes*	2001
Lr4b	Sacred Kingfisher	*Todiramphus sanctus*	2001
LR4c	Australian Shelduck	*Tadorna tadornoides*	1987
LR4c	Australian White Ibis	*Threskiornis molucca*	1987
LR4c	Australian Wood Duck	*Chenonetta jubata*	1987
LR4c	Clamorous Reed Warbler	*Acrocephalus australis*	1987
LR4c	Sacred Kingfisher	*Todiramphus sanctus*	1987
LR4c	White-faced Heron	*Egretta novaehollandiae*	1987
LR4c	White-necked Heron	*Ardea pacifica*	1987
Lr4d	Australian Pelican	*Pelecanus conspicillatus*	2008
Lr4d	Australian Shelduck	*Tadorna tadornoides*	2006
Lr4d	Australian Spotted Crake	*Porzana fluminea*	1988
Lr4d	Australian White Ibis	*Threskiornis molucca*	2008
Lr4d	Australian Wood Duck	*Chenonetta jubata*	2008
Lr4d	Banded Lapwing	*Vanellus tricolor*	1998
Lr4d	Banded Stilt	*Cladorhynchus leucocephalus*	1991
Lr4d	Black Swan	*Cygnus atratus*	2008
Lr4d	Black-fronted Dotterel	*Elseyornis melanops*	1998
Lr4d	Black-tailed Native-hen	*Tribonyx ventralis*	2001
Lr4d	Black-winged Stilt	*Himantopus himantopus*	1991
Lr4d	Chestnut Teal	*Anas castanea*	2009
Lr4d	Clamorous Reed Warbler	*Acrocephalus australis*	2001
Lr4d	Dusky Moorhen	*Gallinula tenebrosa*	2009
Lr4d	**Eastern Great Egret**	***Ardea modesta***	**2001**
Lr4d	Eurasian Coot	*Fulica atra*	2008
Lr4d	**Freckled Duck**	***Stictonetta naevosa***	**1970**
Lr4d	Great Cormorant	*Phalacrocorax carbo*	2001
Lr4d	Great Crested Grebe	*Podiceps cristatus*	1992
Lr4d	Grey Teal	*Anas gracilis*	2001
Lr4d	Hoary-headed Grebe	*Poliocephalus poliocephalus*	1999
Lr4d	**Intermediate Egret**	***Ardea intermedia***	**2001**
Lr4d	**Latham's Snipe**	***Gallinago hardwickii***	**1998**
Lr4d	Little Black Cormorant	*Phalacrocorax sulcirostris*	2001
Lr4d	Little Pied Cormorant	*Microcarbo melanoleucos*	2009
Lr4d	**Magpie Goose**	***Anseranas semipalmata***	**2003**

Reach	Common name	Scientific name	Date of last record
Lr4d	**Marsh Sandpiper**	***Tringa stagnatilis***	**1992**
Lr4d	Masked Lapwing	*Vanellus miles*	2009
Lr4d	Pacific Black Duck	*Anas superciliosa*	2009
Lr4d	Red-kneed Dotterel	*Erythrogonys cinctus*	1992
Lr4d	**Royal Spoonbill**	***Platalea regia***	**1998**
Lr4d	Sacred Kingfisher	*Todiramphus sanctus*	2010
Lr4d	Sharp-tailed Sandpiper	*Calidris acuminata*	1987
Lr4d	Silver Gull	*Chroicocephalus novaehollandiae*	2003
Lr4d	Straw-necked Ibis	*Threskiornis spinicollis*	2009
Lr4d	White-faced Heron	*Egretta novaehollandiae*	2008
Lr4d	White-necked Heron	*Ardea pacifica*	2002
Lr4d	Yellow-billed Spoonbill	*Platalea flavipes*	1999
LR5	Australasian Grebe	*Tachybaptus novaehollandiae*	1999
LR5	Australian Pelican	*Pelecanus conspicillatus*	2000
LR5	Australian Shelduck	*Tadorna tadornoides*	1999
LR5	Australian Spotted Crake	*Porzana fluminea*	2001
LR5	Australian White Ibis	*Threskiornis molucca*	1917
LR5	Australian Wood Duck	*Chenonetta jubata*	2001
LR5	Black-tailed Native-hen	*Tribonyx ventralis*	2001
LR5	Dusky Moorhen	*Gallinula tenebrosa*	2001
LR5	**Eastern Great Egret**	***Ardea modesta***	**2001**
LR5	Great Cormorant	*Phalacrocorax carbo*	2001
LR5	Little Black Cormorant	*Phalacrocorax sulcirostris*	2001
LR5	Little Pied Cormorant	*Microcarbo melanoleucos*	2001
LR5	**Nankeen Night Heron**	***Nycticorax caledonicus hillii***	**1998**
LR5	Pacific Black Duck	*Anas superciliosa*	2001
LR5	**Pacific Golden Plover**	***Pluvialis fulva***	**2012**
LR5	Red-kneed Dotterel	*Erythrogonys cinctus*	2012
LR5	**Royal Spoonbill**	***Platalea regia***	**2001**
LR5	Sacred Kingfisher	*Todiramphus sanctus*	2006
LR5	Sharp-tailed Sandpiper	*Calidris acuminata*	2012
LR5	Straw-necked Ibis	*Threskiornis spinicollis*	2001
LR5	White-faced Heron	*Egretta novaehollandiae*	2000
LR5	White-necked Heron	*Ardea pacifica*	2001
Serp	**Brolga**	***Grus rubicunda***	**1984**
Pyramid	**Australasian Bittern**	***Botaurus poiciloptilus***	**2005**
Pyramid	Australasian Grebe	*Tachybaptus novaehollandiae*	2007
Pyramid	**Australasian Shoveler**	***Anas rhynchotis***	**2005**
Pyramid	Australian Pelican	*Pelecanus conspicillatus*	2007
Pyramid	Australian White Ibis	*Threskiornis molucca*	2011
Pyramid	Australian Wood Duck	*Chenonetta jubata*	2006
Pyramid	**Baillon's Crake**	***Porzana pusilla palustris***	**2005**
Pyramid	Banded Lapwing	*Vanellus tricolor*	2005
Pyramid	Black Swan	*Cygnus atratus*	2005

Reach	Common name	Scientific name	Date of last record
Pyramid	Black-fronted Dotterel	*Elseyornis melanops*	2007
Pyramid	Black-tailed Native-hen	*Tribonyx ventralis*	2005
Pyramid	Black-winged Stilt	*Himantopus himantopus*	2004
Pyramid	**Blue-billed Duck**	***Oxyura australis***	**1993**
Pyramid	**Brolga**	***Grus rubicunda***	**2006**
Pyramid	**Caspian Tern**	***Hydroprogne caspia***	**2005**
Pyramid	Chestnut Teal	*Anas castanea*	2004
Pyramid	Clamorous Reed Warbler	*Acrocephalus australis*	2007
Pyramid	Darter	*Anhinga novaehollandiae*	2006
Pyramid	Dusky Moorhen	*Gallinula tenebrosa*	2011
Pyramid	**Eastern Great Egret**	***Ardea modesta***	**2005**
Pyramid	Eurasian Coot	*Fulica atra*	2006
Pyramid	**Freckled Duck**	***Stictonetta naevosa***	**2004**
Pyramid	**Glossy Ibis**	***Plegadis falcinellus***	**2005**
Pyramid	Great Cormorant	*Phalacrocorax carbo*	2011
Pyramid	Grey Teal	*Anas gracilis*	2011
Pyramid	**Hardhead**	***Aythya australis***	**2005**
Pyramid	Hoary-headed Grebe	*Poliocephalus poliocephalus*	2005
Pyramid	**Intermediate Egret**	***Ardea intermedia***	**2004**
Pyramid	**Latham's Snipe**	***Gallinago hardwickii***	**2005**
Pyramid	**Little Bittern**	***Ixobrychus dubius***	**2006**
Pyramid	Little Black Cormorant	*Phalacrocorax sulcirostris*	2011
Pyramid	**Little Egret**	***Egretta garzetta nigripes***	**1961**
Pyramid	Little Pied Cormorant	*Microcarbo melanoleucos*	2007
Pyramid	**Marsh Sandpiper**	***Tringa stagnatilis***	**2005**
Pyramid	Masked Lapwing	*Vanellus miles*	2007
Pyramid	**Musk Duck**	***Biziura lobata***	**2005**
Pyramid	**Nankeen Night Heron**	***Nycticorax caledonicus australasiae***	**2011**
Pyramid	Pacific Black Duck	*Anas superciliosa*	2008
Pyramid	**Painted Snipe**	***Rostratula australis***	**2004**
Pyramid	Pink-eared Duck	*Malacorhynchus membranaceus*	2005
Pyramid	Purple Swamphen	*Porphyrio porphyrio*	2007
Pyramid	Red-capped Plover	*Charadrius ruficapillus*	2002
Pyramid	Red-kneed Dotterel	*Erythrogonys cinctus*	2004
Pyramid	Red-necked Avocet	*Recurvirostra novaehollandiae*	2002
Pyramid	**Royal Spoonbill**	***Platalea regia***	**2006**
Pyramid	Straw-necked Ibis	*Threskiornis spinicollis*	2008
Pyramid	**White-bellied Sea-Eagle**	***Haliaeetus leucogaster***	**2007**
Pyramid	White-faced Heron	*Egretta novaehollandiae*	2007
Pyramid	White-necked Heron	*Ardea pacifica*	2006
Pyramid	Yellow-billed Spoonbill	*Platalea flavipes*	2007
Frogs			
LR1	Pobblebonk Frog	*Limnodynastes dumerilii insularis*	1978
LR2	Common Froglet	*Crinia signifera*	1997

Reach	**Common name**	**Scientific name**	**Date of last record**
LR2	Southern Brown Tree Frog	*Litoria ewingii*	1997
LR3a	Common Froglet	*Crinia signifera*	1991
LR4d	Plains Froglet	*Crinia parinsignifera*	1995
LR4d	Peron's Tree Frog	*Litoria peronii*	1995
Pyramid	Plains Froglet	*Crinia parinsignifera*	2004
Pyramid	Common Froglet	*Crinia signifera*	2004
Pyramid	Spotted Marsh Frog	*Limnodynastes tasmaniensis*	1982
Pyramid	**Growling Grass Frog**	***Litoria raniformis***	**1982**