Australian Government

Commonwealth Environmental Water

# ENVIRONMENTAL WATER DELIVERY

## Loddon River

AUGUST 2011 V1.0

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Loddon River with birds and dead tree
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Loddon RIver
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# Environmental Water Delivery: Loddon River

Increased volumes of environmental water are now becoming available in the Murray-Darling Basin and this will allow a larger and broader program of environmental watering. It is particularly important that managers of environmental water seek regular input and suggestions from the community as to how we can achieve the best possible approach. As part of the consultation process for Commonwealth environmental water we will be seeking information on:

- community views on environmental assets and the health of these assets
- views on the prioritisation of environmental water use
- potential partnership arrangements for the management of environmental water
- possible arrangements for the monitoring, evaluation and reporting (MER) of environmental water use.

This document has been prepared to provide information on the environmental assets and potential environmental water use in the Loddon River and four Boort district wetlands.

Both the Loddon River and Boort district wetlands support flora and fauna of international, national, regional and local conservation significance, including two waterbirds listed under international agreements. Potential water use options for the Loddon River include the provision of a winter-spring high bankfull flow along Reach 4 to avoid the build-up of organic matter, maintain riparian vegetation condition and support natural geomorphologic processes; as well as provision of a spring fresh to create habitat variability for macrophytes and macroinvertebrates. Options for the Boort wetlands include the provision of water to complete the desired filling and drying pattern to maintain/rehabilitate the health of aquatic plant communities and fringing vegetation.

A key aim in undertaking this work was to prepare scalable water use strategies that maximise the efficiency of water use and anticipate different climatic circumstances. Operational opportunities and constraints have been identified and delivery options prepared. This has been done in a manner that will assist the community and environmental water managers in considering the issues and developing multi-year water use plans.

The work has been undertaken by consultants on behalf of the Commonwealth Department of Sustainability, Environment, Water, Population and Communities. Previously prepared work has been drawn upon and discussions have occurred with organisations such as the Victorian Department of Sustainability and Environment, Goulburn-Murray Water, North Central Catchment Management Authority, Goulburn Broken Catchment Management Authority and the Murray-Darling Basin Authority.

Management of environmental water will be an adaptive process. There will always be areas of potential improvement. Comments and suggestions including on possible partnership arrangements are very welcome and can be provided directly to: ewater@environment.gov.au. Further information about Commonwealth environmental water can be found at www.environment.gov.au/ewater.

Commonwealth Environmental Water
Department of Sustainability, Environment, Water, Population and Communities
GPO Box 787, Canberra ACT 2601
Tel: +61 2 6275 9245

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# Acronyms

| ACRONYM | MEANING |
|---|---|
| BE | Bulk Entitlement |
| CAMBA | China-Australia Migratory Bird Agreement |
| CEWH | Commonwealth Environmental Water Holder |
| COAG | Council of Australian Governments |
| DO | Dissolved oxygen |
| DPI | Victorian Department of Primary Industries |
| DSE | Victorian Department of Sustainability and Environment |
| EC | Electrical conductivity |
| EPA | Victorian Environment Protection Authority |
| EVC | Ecological vegetation classes |
| eWater CRC | eWater Cooperative Research Centre |
| GBCL | Goulburn-Broken-Campaspe-Loddon |
| GB CMA | Goulburn Broken Catchment Management Authority |
| G-MW | Goulburn-Murray Water |
| IVTs | Inter-valley transfers |
| JAMBA | Japan-Australia Migratory Bird Agreement |
| MDBA | Murray-Darling Basin Authority |
| LREFSP | Loddon River Environmental Flows Scientific Panel |
| NC CMA | North Central Catchment Management Authority |
| NERWMP | North East Regional Water Monitoring Partnership |
| NCRHS | North Central River Health Strategy |
| NRSWS | The Northern Region Sustainable Water Strategy |
| NVIRP | Northern Victoria Irrigation Renewal Project |
| ROKAMBA | Republic of Korea – Australia Migratory Bird Agreement |
| SEWPaC | Australian Government Department of Sustainability, Environment, Water, Population and Communities |
| SKM | Sinclair Knight Merz |
| TLM | The Living Murray |
| VEFMAP | The Victorian Environmental Flows Monitoring and Assessment Program |
| VEWH | Victorian Environmental Water Holder |
| VWQMN | Victorian Water Quality Monitoring Network |

# PART 1:
## Management Aims

# 1. Overview

## 1.1 Scope and purpose of this document

Information provided in this document is intended to help establish an operational planning framework that provides scalable strategies for environmental water use based on the demand profiles for selected assets. This document outlines the processes and mechanisms that will enable water use strategies to be implemented in the context of river operations and delivery arrangements, water trading and governance, constraints and opportunities. It specifically targets large-scale water use options for large volumes of environmental water.

To maximise the systems' benefit, three scales of watering objectives are expressed:

1. Water management area (individual wetland features/sites within an asset).
2. Asset objectives (related to different water resource scenarios).
3. Broader river system objectives across and between assets.

This document focuses on assets in the Loddon River and Boort wetlands system in northern Victoria. It includes options for the use of water held in Loddon storages, as well as options that might be pursued with access to environmental water held in the Goulburn system.

As part of this project, assets and potential watering options have been identified for regions across the Basin. This work has been undertaken in three steps:

1. Existing information for selected environmental assets has been collated to establish asset profiles, which include information on hydrological requirements and the management arrangements necessary to deliver water to meet ecological objectives for individual assets.
2. Water use options have been developed for each asset to meet watering objectives under a range of volume scenarios. Use of environmental water will aim to maximise environmental outcomes at multiple assets, where possible. Water use options will provide an "event ready" basis for the use of environmental water. Options are expected to be integrated into a five-year water delivery program.
3. Processes and mechanisms that are required to operationalise the environmental water use strategies are documented and include such things as:
   - delivery arrangements and operating procedures
   - water delivery accounting methods that are either currently in operation at each asset or methodologies that could be applied for accurate accounting of inflow, return flows and water 'consumption'
   - decision triggers for selecting any combination of water use options
   - approvals and legal mechanisms for delivery and indicative costs for implementation.

## 1.2 Catchment and river system overview

The Loddon River catchment covers approximately 1.5 million hectares or about 6.8 per cent of the area of Victoria. The river rises on the northern slopes of the Great Dividing Range, south of Daylesford, before flowing 430 kilometres northward to join the Murray River downstream of the Gunbower and Koondrook-Perricoota Forests (NC CMA 2010).

The Loddon River resides within a number of local government areas. These include the Loddon Shire, City of Greater Bendigo, Hepburn Shire, Central Goldfields Shire, Mt Alexander Shire, Gannawarra Shire and Campaspe Shire.

Land tenure along the Loddon River is a mixture of freehold, conservation reserve and State forest. Intensive horticulture occurs in the upper catchment, and mixed farming and cereal growing dominates the mid and lower catchments. Land use along the river is predominantly:

- Grazing of natural vegetation.
- Dryland agriculture and plantations (grazing modified pastures, cropping).
- Irrigated agriculture and plantations (irrigated modified pastures, irrigated perennial horticulture).
- Intensive uses (residential, services).
- Conservation and natural environments (nature conservation, managed resource protection).
- Remnant wetlands / marshes.

Three main streams of the upper catchment are the Loddon River, Tullaroop Creek and Bet Bet Creek, all meeting at Laanecoorie Reservoir. The Loddon River then flows towards the Murray River (Figure 1). In addition to numerous small water storages, the three main storages in the upper catchment are: Cairn Curran Reservoir (147,000 ML capacity), Tullaroop Reservoir (73,000 ML capacity) and Laanecoorie Reservoir (8,000 ML capacity).

Environmental flow proposals have been developed for the four main reaches (Figure 1, Section 1.3) of the Loddon River downstream of the major flow regulating structures (LREFSP 2002, NC CMA 2010). Drought and low water availability led to a Qualification of Rights in 2007 and the subsequent management of river flows to ensure the survival of key ecosystem assets (Cottingham et al. 2010). It is only with increased rainfall runoff and water storage in 2010 that the reinstatement of the environmental flow regime can be reconsidered.

At high flows the Loddon River breaks, at several locations, into the Wandella Creek to the west and the Tragowel Plains to the east. The Waranga Western Channel crosses the Loddon River catchment south of Boort and at the Loddon Weir. It carries water from the Goulburn system that can be released to the lower reaches of the Loddon River. The Macorna Channel crosses underneath the Loddon River upstream of Kerang to supply Murray River water to irrigators in the Torrumbarry system. This report does not explicitly consider the Loddon River from Kerang Weir to the Murray River, as managed flows in this Reach are predominantly supplied from diversions from the Murray River at Torrumbarry Weir.

The Boort district wetlands include (but are not limited to) Lake Boort, Lake Meran, Little Lake Meran, Lake Yando, and Lake Leaghur. They are a series of wetlands located to the west of the Loddon River and north of Loddon Weir (Figure 2), and are considered to be regionally important. Shallow freshwater marshes, such as Lake Yando, Lake Leaghur and Lake Boort support diverse vegetation such as reeds, river red gum, water couch, water milfoils and water ribbons (*Triglochin spp.*). These provide habitat for a variety of biota such as waterbirds, waterfowl and frogs.

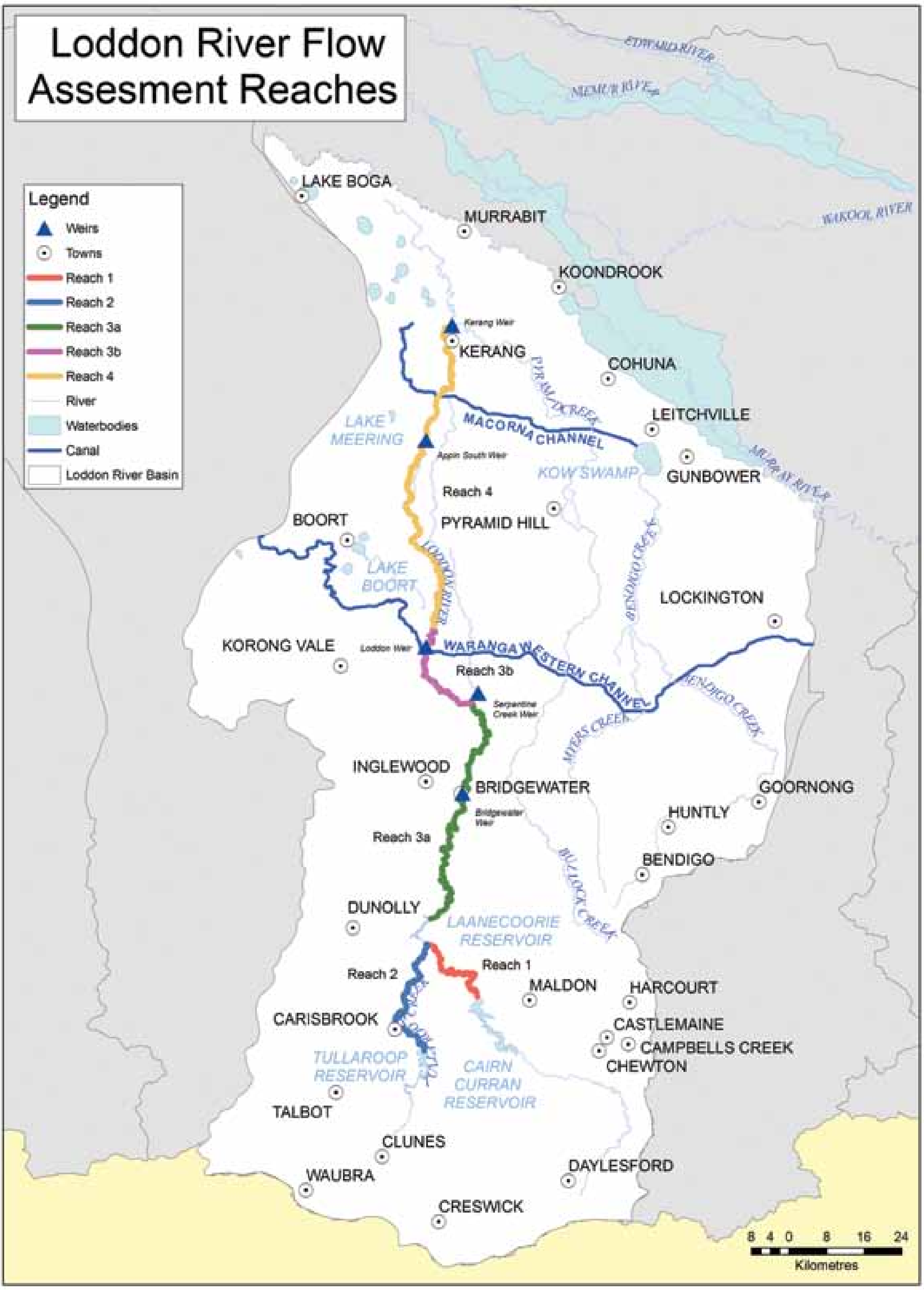


**Figure 1:** Loddon River flow assessment reaches (SEWPaC 2011).

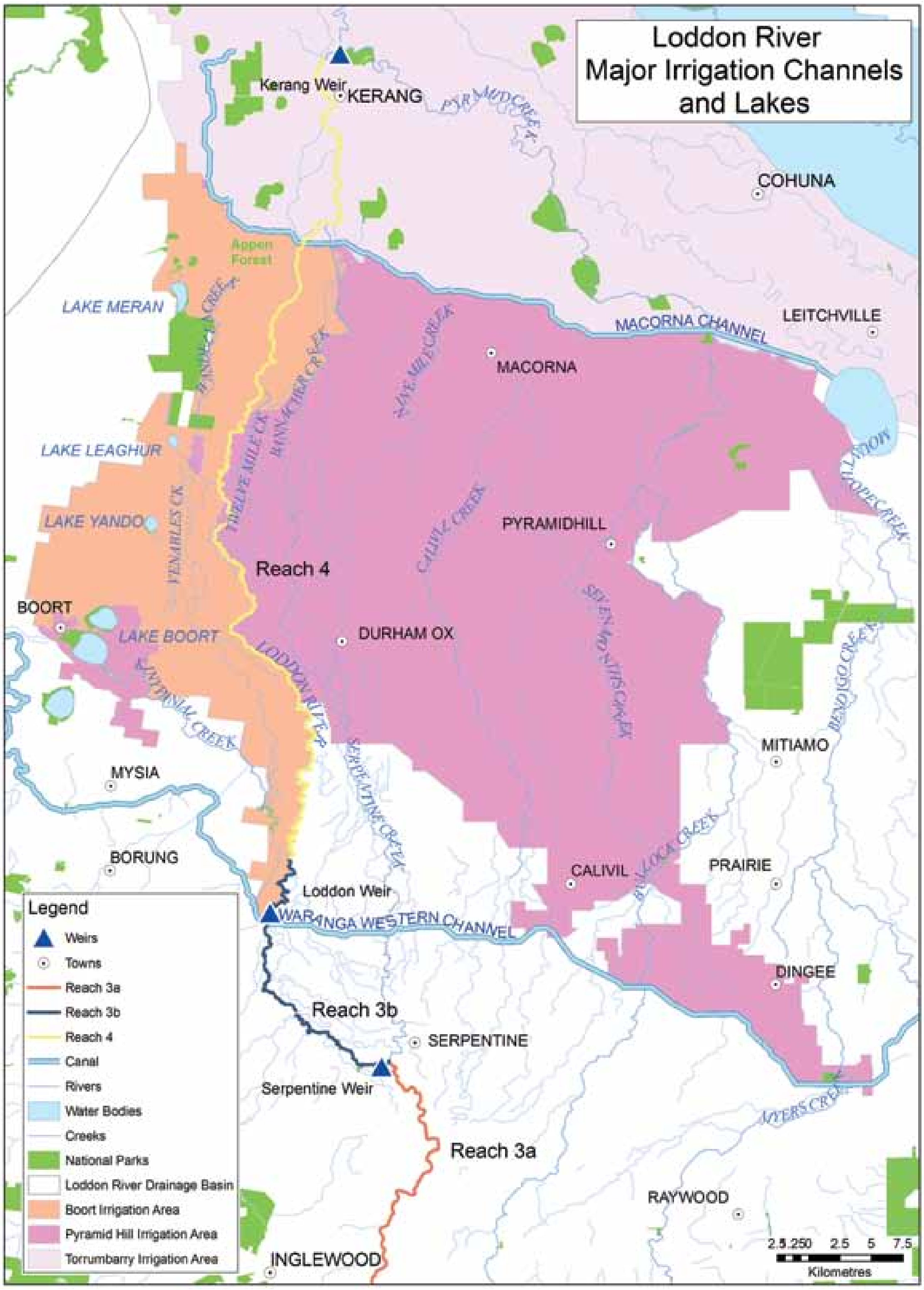


**Figure 2:** Loddon River major irrigation channels and lakes (SEWPaC 2011).

## 1.3 Overview of river operating environment

Environmental water is managed by the North Central Catchment Management Authority (NC CMA), in cooperation with the Victorian Environmental Water Holder (VEWH), Victorian Department of Sustainability and Environment (DSE) and Goulburn-Murray Water (G-MW), who manages river operations. Under the Bulk Entitlement (BE), the Loddon River is managed as four reaches:

Reach 1: Loddon River – Cairn Curran Reservoir to Laanecoorie Reservoir.
Reach 2: Tullaroop Creek – Tullaroop Reservoir to Laanecoorie Reservoir.
Reach 3a: Loddon River – Laanecoorie Reservoir to Serpentine Weir.
Reach 3b: Loddon River – Serpentine Weir to Loddon Weir.
Reach 4: Loddon River – Loddon Weir to Kerang Weir.

The river is generally operated to meet BE conditions at the top of Reach 4. Reach 5 (downstream of Kerang Weir to the Murray River) is operationally managed through the Torrumbarry Irrigation Area and forms part of the Victorian Murray BE. It is not specifically considered as part of the Loddon BE process and is not included in this document.

The Loddon River is highly regulated down to Loddon Weir to supply irrigation, stock and domestic and urban water demands. This has a major influence on the river's natural flow regime, including altered seasonal patterns of baseflow, reduced baseflow magnitude and reduced frequency of bankfull and flood flows (LREFSP 2002). Cairn Curran and Tullaroop Reservoirs are the main storages that collect water from the upper parts of the catchment. Laanecoorie Reservoir is used as a re-regulating storage for releases from Cairn Curran and Tullaroop Reservoirs. Water is drawn off Serpentine Weir to supply irrigators along Serpentine Creek. Flow into the Loddon River mixes with supply from the Waranga Western Channel at Loddon Weir pool. Loddon Weir to Kerang Weir is unregulated. The Macorna Channel, which is supplied from Torrumbarry Weir, crosses the Loddon River without interaction, apart from minor outfalls associated with channel operation. The lower Loddon River mixes with Pyramid Creek at Kerang Weir. Pyramid Creek carries irrigation supplies diverted from the Murray River at Torrumbarry Weir.

During high flow periods, there are numerous breakaway flows. Flood breakouts occur to the east (to the Tragowel Plains) and west (Wandella, Venables and Kinypanial Creeks and other tributaries) of the Loddon River. Water loss between Loddon Weir and Kerang Weir is poorly understood and high-flow data is uncertain.

Water reaches the Boort wetlands complex via local waterways and/or the local irrigation system. Prior to regulation, the wetlands in the complex would have filled in winter-spring. Regional development and water regulation caused isolation of some wetlands. Others were maintained as permanent or semi-permanent water bodies. The wetlands are now managed for their environmental values and a more natural cycle of filling (winter-spring) and drying has been reinstated.

# 2. Ecological values, processes and objectives

## 2.1 Summary of ecosystem values

The Loddon River and Boort district wetlands support flora and fauna of international, national, regional and local conservation significance (see NC CMA 2010a, b, c, Appendix 5). This includes waterbirds listed under international agreements (including JAMBA, CAMBA, ROKAMBA, and Bonn), threatened native fauna (including native fish) and flora.

The Loddon River provides breeding habitat for important fish species, such as the Murray cod and golden perch. Features such as pools (including weir pools) serve as important refugia for the survival of organisms that can recolonise reaches following periods of drought. After a period of cease-to-flow, protecting and then connecting in-channel habitat is important for the recovery of the river. The riparian zone of the Loddon River also supports important vegetation such as river red gums, chenopod grassland, lignum swamp and box-ironbark forest. The Loddon River is, therefore, a high priority for environmental water in the *North Central Regional River Health Strategy* and in annual watering plans written by the North Central CMA (NC CMA 2010).

Collectively, the Boort wetlands provide important breeding, feeding and refuge habitat for waterbirds (Parks Victoria 2003, NC CMA 2010b, c, d). At the landscape scale, the wetlands provide a great diversity of habitat types and drought refuges in a heavily modified landscape. The wetlands are visited by waterbird species (including those listed under JAMBA, CAMBA, ROKAMBA) such as Caspian tern, whiskered tern, great egret, Australasian shoveller, freckled duck, hardhead and blue-billed duck. The wetlands also support a variety of vegetation assemblages, including ecological vegetation classes (EVC) such as river red gum swamp, black box woodland, tall marsh and lignum swamp.

**Table 1:** General ecological objectives for targeted water use.

| Water management area | Broad scale system objective | Ecological Objectives |
|---|---|---|
| Loddon River below the Loddon storages (Tullaroop, Cairn Curran and Laanecoorie) to Kerang Weir. | Deliver winter-spring flows that will provide a flow regime and conditions suitable to support habitat, flora and fauna. Sustain them beyond spring with an appropriate summer-autumn flow regime.<br><br>Provide ecological connections to nearby floodplain ecosystems (e.g. Boort wetlands) as well as with the Murray River. | Deliver winter-spring bankfull and baseflow to avoid the build-up of organic matter, maintain riparian vegetation health and support natural geomorphologic processes.<br><br>Deliver spring freshes and baseflow to provide habitat, as well as movement and breeding cues for fauna such as native fish.<br><br>Deliver summer-autumn baseflow and freshes to provide habitat and suitable water quality in the river channel, as well as provide drought refuges for vulnerable biota.<br><br>Deliver a flow regime that over time will support the biodiversity and asset objectives outlined in SKM (2010) and LREFSP (2002). |
| Boort wetland complex including (but not limited to) Lake Boort and Little Lake Boort, Lake Leaghur, Lake Meran and Lake Yando. | Maintain a more natural pattern of filling and drying at individual wetlands and across the wetland complex. | Deliver water to complete the desired filling and drying patterns at individual wetlands (NC CMA 2010b, c, d).<br><br>This will maintain/rehabilitate aquatic plant communities and the health of fringing vegetation. It will also provide habitat and breeding opportunities for aquatic fauna and waterbirds. |

More detailed watering objectives are presented in section 3.

# 3. Watering objectives

## 3.1 Broad-scale ecosystem objectives

### 3.1.1 Murray-Darling Basin

Work undertaken by the Murray-Darling Basin Authority (MDBA 2010) has produced a number of broad ecosystem objectives, the following of which are relevant when considering options for the use of environmental water:

- Maintain and improve the ecological health of the Basin, and in doing so optimise the social, cultural, and economic well-being of Basin communities.
- Improve the resilience of key environmental assets, water-dependent ecosystems and biodiversity in the face of threats and risks that may arise in a changing environment.
- Maintain appropriate water quality, including salinity levels, for environmental, social, cultural and economic activity in the Basin.

These and ecological objectives developed for the Loddon River system (see Table 1) will be important considerations when allocating environmental water in the Loddon system.

### 3.1.2 Loddon River

Flow-related ecosystem objectives for the Loddon River below Cairn Curran Reservoir (LREFSP 2002, Table 2) were outlined in the development of environmental flow proposals for Reaches 1–4. They were subsequently included in the Loddon River (Environmental Reserve) Bulk Entitlement (BE) Order 2005 (see Section 8.1.2). Flow proposals for Reach 4 and 5 were revisited (SKM 2010) in light of changed conditions (e.g. much of Reach 4 had been dry in recent years) and availability of better hydrological information, which had limited the recommendation of LREFSP (2002). The more recent objectives for Reach 4 are given in Table 3. The objectives for Reaches 1–3b remain unchanged – the fundamental management approach is to maintain, as a minimum, passing flows according to the Loddon BE.

**Table 2:** Summary of suggested environmental flow objectives for the Loddon River (LREFSP 2002).

| Biodiversity Objective | No. | Process | Draft Flow Objective | |
|---|---|---|---|---|
| | | | Flow Component | Timing |
| Restore or maintain River blackfish population | 1a | Habitat availability | Low (depth >0.4m) | All year |
| | 1b | Breeding/Recruitment | Low | Spring |
| | 1c | Movement | Low | All year |
| Restore or maintain native fish community (Marray cod, Golden perch and Silver perch) | 2a | Available habitat and movement for all fish | All (depth >0.5m) | All year |
| | 2b | Breeding cues for Murray cod | Freshes | Winter/Spring |
| | 2c | Breeding cues for Golden perch | Freshes | Winter/Spring |
| | 2d | Breeding cues for Silver perch | Freshes | Winter/Spring |
| Reinstate or maintain a mosaic of aquatic macrophytes | 4a | Colonisation | Low | Spring |
| | 4b | Disturbance | Low/Cease-to-flow | Summer |
| | 4c | Habitat maintenance | Freshes | All year |
| Improve in-stream macrophyte habitat | 4d | Colonisation/growth | Low | Spring/Summer |
| Improve submerged macrophyte habitat | 4e | Colonisation/growth | Low (depth <0.3m) | Spring/Summer |
| Reinstate a mosaic of bank vegetation | 5a | Colonisation/growth | All | Spring/Summer |
| | 5b | Disturbance | Low/Cease-to-flow | Summer |
| | 5c | Wetting | Freshes | Winter/Spring |
| Reverse terrestrialisation of bank/bench grasses | 6 | Disturbance | Freshes/High | Winter/Spring |
| Maintain red gum regeneration | 7a | Wetting | Overbank | Spring |
| Restore or maintain floodplain/wetland processes | 7b | Inundation | Overbank | Spring |
| Clean bed surface | 8a | Disturbance | Freshes | Any time |
| Restore or maintain pools | 8b | Scour | High | Any time |
| Restore or maintain runs | 8c | Disturbance | Freshes/High | Any time |
| Re-shape in-channel forms to maintain physical habitat diversity and complexity | 8d | Scour/deposition | Freshes/High | Any time |
| Scour silt on bed | 8e | Scour | High/Overbank | Any time |
| Restore or maintain snag | 9 | Submergence | Low | Any time |
| Entrain organic litter – carbon cycling | 10 | Disturbance | High | Winter |

**Table 3:** Summary of proposed environmental watering objectives and anticipated responses for Reach 4 (from SKM 2010).

| Asset | Objective | Function | Flow component | Timing | Expected response |
|---|---|---|---|---|---|
| Geomorphology | Maintain channel form and processes along the main channel of the Loddon and its system of distributaries, such as Twelve Mile Creek, Kinypanial Creek, Bannagher Creek and Venables Creek. | Channel maintenance. | Freshes / high flows | Summer and winter | • Maintain channel complexity, pools and benches. |
| | | Channel forming processes. | Bankfull | Winter, spring or early summer | • Maintain channel form and floodplain features as a bankfull flow may also engage distributary channels. |
| | | Creation of new flow paths across floodplain. | Bankfull and overbank | Winter-spring | • Engage floodplain and distributary channels.<br>• Formation of new distributary channels. |
| Vegetation | Maintain/rehabilitate in-stream aquatic vegetation and ecological processes in main channel.<br><br>Control existing invasion of main channel with non-aquatic species.<br><br>Maintain or rehabilitate flood-dependent riparian and floodplain ecological vegetation classes (EVC).<br><br>Rehabilitate river-floodplain ecological interactions and ecological processes on floodplain. | Establish aquatic environment for in-stream aquatic vegetation (e.g. pondweeds, water ribbons etc). | Low flow | Summer and winter | • Re-establishment of aquatic vegetation in in-stream channel.<br>• Progressive control of invading river red gum in in-stream environments.<br>• Possible (but uncertain) control of invading common reed in in-stream environments.<br>• Improvement in condition of adult riparian and floodplain vegetation, especially river red gum.<br>• Improvement in recruitment of juvenile plants into riparian and floodplain vegetation.<br>• Increased floristic and structural complexity of floodplain vegetation (particularly understorey).<br>• Engagement of floodplain with river: translocation of organic detritus and fauna/flora across floodplain-river ecotone. |
| | | Drown-out invading terrestrial plant species (e.g. common reed, river red gum). | Low flow | Winter | |
| | | Maintain adults of plant species in relevant riparian and floodplain EVCs (e.g. river red gum, black box). | Bankfull and overbank | Winter, spring or early summer | |
| | | Facilitate recruitment of juveniles into relevant riparian and floodplain EVCs. | Bankfull and overbank | Winter, spring or early summer | |
| | | Engage floodplain with river to entrain litter and allow movement of fauna across river floodplain. | Overbank | Winter-spring | |

| Asset | Objective | Function | Flow component | Timing | Expected response |
|---|---|---|---|---|---|
| Water quality | Improve water quality.<br><br>Reduce incidence and severity of blackwater events.<br><br>Limit impacts associated with acid sulfate soils (ASS). | Connecting flow sufficient to maintain water quality, prevent algal blooms and acidity from acid sulfate soils. | Low | Summer | • Annual bankfull flows are required to entrain organic matter that has accumulated in the channel margins to decrease the risk of blackwater events during summer. Continuously flowing water and occasional freshes in summer will prevent algal blooms and ensure that adverse water quality conditions (e.g. low DO, high temperatures, acidity from acid sulfate soils) do not develop. Note: summer fresh should not be delivered in the absence of winter/spring bankfull flows.<br>• Cease to flow periods may be used to control the severity of acid sulfate soils by periodically allowing the sediments to oxygenate. |
| | | Turn over water in pools for re-oxygenation of water column and sediments.<br><br>Entrain terrestrial organic matter that has accumulated on bars and benches. | Fresh | Summer | |
| | | Transport organic matter that has accumulated in the channel. | Bankfull | Winter | |
| | | Control acid sulfate soils. | Cease to flow | Summer | |
| Fish | Maintain pools or depressions in the bottom of channels that fish may opportunistically use when wet. | Scour pools to provide depth and habitat variety in the bottom of the channel. | High to bankfull flows | Summer and winter | • Provide pools and debris in channels that will improve the quality of fish habitats.<br>• Expect fish to use this reach opportunistically when wet. Small-bodied fish may complete their life cycle in wet periods. Large-bodied fish are more likely to use this habitat on a temporary basis. |
| | | Facilitate movement of fish. | High flows | Spring and summer | |
| | | Maintain aquatic habitat. This is probably a lower priority for Reach 4 because it will dry out periodically. | Low flows | Winter and spring | |
| Macroinvertebrates | Maintain habitat quality. | Inundate exposed roots, emergent vegetation and woody debris. | Low flows | All year round | • Increase diversity, abundance and distribution of macroinvertebrates throughout the reach. |
| | | Flush sediment from hard substrate elements. | Fresh | Summer | |

Environmental flow proposals for the Loddon River (particularly Reach 4) include provisions for bankfull flows, rather than large overbank flows. Bankfull flows engage with important geomorphic features such as anabranches and flood-runners. Overbank flows occur naturally and are desirable but have not been the focus of environmental flow recommendations due to the risk associated with flooding private land.

Options for using environmental water to meet flow objectives for the Loddon River will vary depending on ecosystem needs at any particular time, as well as the availability of environmental water held in the Goulburn and Campaspe systems. In isolation, the volume of Commonwealth environmental water held in Loddon storages is small and would only make a small contribution in meeting the flow objectives along the Loddon River. It could, however be used to water wetland assets in the Boort wetland complex. If Commonwealth environmental water is available from the Goulburn or Campaspe systems, it could be used to achieve desired environmental outcomes in the Loddon River (Reach 4) and the Boort wetlands.

### 3.1.3 Boort wetlands

In summary, objectives for the Boort wetlands are to:

- Maintain emergent aquatic plant communities.
- Maintain health of the fringing vegetation, including river red gum, blackbox, tangled lignum and cane grass.
- Restore open water/submerged aquatic macrophyte habitat in the deeper sections of the wetlands.
- Restore habitat and breeding opportunities for waterbirds, fish, frogs and invertebrates (NC CMA 2010b, c, d).

## 3.2 Asset watering objectives

### 3.2.1 Loddon River

Minimum flows and summer freshes are delivered to Reaches 1–3b under Bulk Entitlement arrangements. Flows are complemented by G-MW's river operations in most years, and by natural flows in average to wet scenarios, particularly if storages spill. Environmental water being sourced from Tullaroop and/or Cairn Curran reservoirs for delivery to Reach 4 is also likely to have environmental benefits in Reaches 1 to 3b as it passes through the system (NC CMA 2011). Environmental water in the Loddon storages may be used to supplement winter/spring baseflows to achieve flow objectives for Reach 4. If environmental water is available from the Goulburn or Campaspe systems, this may contribute to achieving ecosystem objectives in Reach 4, downstream of the Waranga Western Channel.

Environmental watering objectives for Reach 4 (SKM 2010) are presented in Table 3. Overall, priority should go to:

- bankfull flow events (three to five times per decade)
- winter minimum flows
- spring freshes
- summer freshes
- summer minimum flows.

The priority order listed above is due to Reach 4 remaining dry for the three years leading up to the 2010–11 floods. A bankfull event is required to reduce the risk of poor water quality (low dissolved oxygen, high salinity, low pH) that might be expected after prolonged drying. SKM (2010) recommends that a flow component only be implemented if it and the higher priority components could be provided into the future. This ensures supply to higher priority components before commencing a lower priority component in 2011.

### 3.2.2 Boort wetlands

The small volume of Commonwealth environmental water (1,700 ML as at October 2010) limits the ecosystem objectives that might be achieved in the Loddon River. If only 1,700 ML is available to the Loddon system, deployment to the Boort wetlands is recommended. Further details of the Boort wetlands and their preferred water regimes are presented in Table 4, which is based on the ecological objectives and preferred hydrological regime identified by the North Central CMA (2010b, c, d). Information on Lake Yando is provided as an example in Appendix 4. Note that Table 4 is based on the four main wetlands in the complex, for which there are current watering plans. Other wetlands in the Boort complex may also be considered for watering in the future.

**Table 4:** Desired filling regime of the Boort wetlands (NC CMA 2010b, c, d).

| | Lake Yando | Lake Leaghur | Lake Boort | Lake Meran |
|---|---|---|---|---|
| Water regime | Fill and allow to dry over 18 months. | Fill and allow to dry over 18 months. | Fill with unregulated flow events from the Loddon River. | Fill and maintain as permanent for at least 9 in 10 years. |
| Minimum filling frequency | 1 in 5 years. | 1 in 5 years. | | |
| Optimum filling frequency | 1 in 3 years. | 1 in 3 years. | 1 in 3 years. | 1 in 10 years. |
| Maximum filling frequency | 1 in 2 years. | 1 in 2 years. | | |
| Timing | Winter–spring. | Winter–spring. | Winter–spring. | Winter–spring. |
| Other | Provide top-ups if there are bird breeding events. | Release a small pulse annually to maintain refuge habitat near the outfall. | | Release a small pulse annually to maintain refuge habitat near the outfall. |

## 3.3 Watering objectives under various climatic regimes

Proposed objectives and watering options for Reach 4 of the Loddon River and the Boort wetlands are presented in Table 5. Management of the flow regime for the Boort wetlands is to achieve a more natural filling and drying cycle for each wetland. This involves cycles of filling a wetland, then topping up to extend the drying phase in a subsequent year, and then followed by a dry phase. The length of each phase varies for each wetland (see NC CMA 2010b, c, d for details).

It should be noted that the scenarios for extreme dry, dry, median and wet years identified in Table 5 are only indicative of what might occur. Such categorisations infer that a particular year remains constant (i.e. a dry year remains dry) and independent from other scenarios. In reality, climatic and flow conditions can vary seasonally and annually. In addition, climatic conditions are not always indicative of flow conditions and vice versa. For example, a dry spring may be followed by a wet summer, with water availability being that of a median year overall. Climatically, conditions may be dry or extreme dry but because of water demand and delivery, flow conditions in a river may be that of a median or wet year.

In addition, the scenarios for extreme dry, dry, median and wet years identified in Table 5 do not deal with sequences of years. For example, most of the Boort wetlands being filled in 2010–11 by flood flows will not require filling again in 2011–12, regardless of the climate scenario in 2011–12. In short, specific environmental water releases such as those outlined in Table 4 may not be required in all years.

**Table 5:** Summary of proposed objectives for the Loddon River (Reach 4) and Boort wetlands.

| | Management objectives for specific water availability scenarios | | | |
|---|---|---|---|---|
| | Extreme dry | Dry | Median | Wet |
| | Goal: Avoid damage to key ecological assets | Goal: Ensure ecological capacity for recovery | Goal: Maintain ecological health and resilience | Goal: Improve and extend healthy aquatic ecosystems |
| Water availability | Minimum allocation on record | 30th percentile year | 50th percentile year | 70th percentile year |
| **Loddon River** | | | | |
| Reach 4 | No allocation will be made for the Loddon (NC CMA 2009). No releases unless a commitment can be made to supply a high-bankfull flow (3,500 ML/d for 6 days) as well as minimum winter flows.<br>Environmental water can contribute to other releases to provide:<br>• A bankfull flow (3,500 ML/d for 6 days).<br>• Minimum flows in winter (100 ML/d).<br>Carry over any excess environmental water. | No releases unless a commitment can be made to supply a winter-spring, high bankfull flow (3,500 ML/d for 6 days) as well as minimum winter flows. The winter-spring bankfull flow is to dilute and flush potentially acid water before reinstating a baseflow regime.<br>Environmental water can be used to contribute to:<br>• A bankfull flow (3,500 ML/d for 6 days).<br>• Minimum flows in winter (100 ML/d).<br>• A spring fresh of 750 ML/d for 10 days to increase flow and thus habitat variability for macrophytes and macroinvertebrates.<br>However, the North Central CMA would seek to have arrangements in place to secure the allocations listed above in > 80% of years.<br>Carry over environmental water if no other water is committed. | Environmental water can be used to contribute to:<br>• Deliver a high bankfull flow (3,500 ML/d for 6 days) in spring to maintain or improve water quality and maintain and where possible rehabilitate riparian vegetation and floodplain habitats. This includes distributary channels, wetlands and the Leaghur State Forest (SKM 2010).<br>• Deliver a winter low flow minimum of 100 ML/d (if there is sufficient water to deliver in > 80% of years) to prevent terrestrial vegetation from encroaching into the river channel.<br>• Deliver a spring fresh of 750 ML/d for 10 days to increase flow and thus habitat variability for macrophytes and macro invertebrates.<br>Environmental water can be used to top-up BE water to:<br>• Contribute (if necessary) to the 3,500 ML/d for 6 days required to start flows in Reach 4.<br>• Maintain winter baseflow at 100 ML/d May–October, inclusive.<br>• Deliver a spring fresh of 750 ML/d for 10 days. | Environmental water can be used to contribute to:<br>• Deliver a high-bankfull flow (3,500 ML/d for 6 days) in spring to maintain or improve water quality and maintain and where possible rehabilitate riparian vegetation and floodplain habitats. This includes distributary channels, wetlands and the Leaghur State Forest (SKM 2010).<br>• Deliver a winter low flow minimum of 100 ML/d (if there is sufficient water to deliver in >80% of years) to prevent terrestrial vegetation from encroaching into the river channel.<br>• Deliver a spring fresh of 750 ML/d for 10 days to increase flow and thus habitat variability for macrophytes and macroinvertebrates.<br>Environmental water to be used to top-up BE water to:<br>• Contribute (if necessary) to the 3,500 ML/d for 6 days required to start flows in Reach 4.<br>• Maintain winter baseflow at 100 ML/d May–October, inclusive.<br>• Deliver a spring (and potentially summer) fresh of 750 ML/d for 10 days. |

| | Management objectives for specific water availability scenarios | | | |
|---|---|---|---|---|
| | Extreme dry | Dry | Median | Wet |
| | Goal: Avoid damage to key ecological assets | Goal: Ensure ecological capacity for recovery | Goal: Maintain ecological health and resilience | Goal: Improve and extend healthy aquatic ecosystems |
| Water availability | Minimum allocation on record | 30th percentile year | 50th percentile year | 70th percentile year |
| Boort wetlands The small volume of Commonwealth environmental water (1,700 ML of entitlements as at October 2010, with total volume available subject to allocation) limits the ecosystem objectives that might be achieved in the Loddon River. If only 1,700 ML is available to the Loddon system, deployment to the Boort wetlands is recommended. Further details of the Boort wetlands and their preferred water regimes are presented in Table 4, which is based on the ecological objectives and preferred hydrological regime identified by the North Central CMA (2010b, c, d). Information on Lake Yando is provided as an example in Appendix 4. Note that Table 4 is based on the four main wetlands in the complex, for which there are current watering plans. Other wetlands in the Boort complex may also be considered for watering in the future. | | | | |
| Lake Yando | Fill: 0.9–1.0 GL<br>Top-up: 0.3 GL | Fill: 0.9–1.0 GL<br>Top-up: 0.3 GL | Fill: 0.9–1.0 GL<br>Top-up: 0.3 GL | Fill: 0.9–1.0 GL<br>Top-up: 0.3 GL |
| Lake Leaghur | Fill: 0.9–1.3 GL<br>Top-up: 0.4 GL | Fill: 0.9–1.3 GL<br>Top-up: 0.4 GL | Fill: 0.9–1.3 GL<br>Top-up: 0.4 GL | Fill: 0.9–1.3 GL<br>Top-up: 0.4 GL |
| Lake Boort | Fill: 6.0–9.0 GL<br>Top-up: 3.0 GL | Fill: 6.0–9.0 GL<br>Top-up: 3.0 GL | Fill: 6.0–9.0 GL<br>Top-up: 3.0 GL | Fill: 6.0–9.0 GL<br>Top-up: 3.0 GL |
| Lake Meran | Fill: 10.0–14.0 GL<br>Top-up: 1.4–2.7 GL | Fill: 10.0–14.0 GL<br>Top-up: 1.4–2.7 GL | Fill: 10.0–14.0 GL<br>Top-up: 1.4–2.7 GL | Fill: 10.0–14.0 GL<br>Top-up: 1.4–2.7 GL |

# PART 2:
## Water Use Strategy

# 4. Environmental water requirements

## 4.1 Baseline flow characteristics

Commonwealth environmental water in the Loddon system is available from the headworks storages for regulated river delivery down to Loddon Weir, whilst entitlements for the Goulburn and Campaspe system are potentially available from the Waranga Western Channel, which crosses the Loddon River at Loddon Weir.

The daily flow model of the Loddon River is known as the Goulburn-Broken-Campaspe-Loddon REALM model. At the time of preparing this report, this model had not been updated for several years and many of the assumptions in the model were out of date. Hence gauged flow data has been used in the information presented below.

The period of data assessed is 1976 to 2010. This period of record includes a range of climatic conditions including the recent drought conditions and wetter conditions during the 1970s.

Table 6 and Table 7 show that the river has no flow in an extreme dry year. This reflects the very recent drought years. In these tables, the 30$^{th}$ percentile flow is the flow that is not exceeded on 30 per cent of all days in each month over the modelled period (i.e. 30 per cent of July days had a flow at Serpentine Weir below 20 ML/d over the historical period). Flows at Serpentine Weir, upstream of the Waranga Western Channel, are considerably higher than flows downstream of the channel due to irrigation deliveries to the Boort Irrigation Area via the channel. Current flows may be higher than historical flows, due to the introduction of minimum passing flows in the Loddon River (Environmental Reserve) Bulk Entitlement (BE) Order 2005. Note that the values in Table 6 and 7 are derived independently for each month. In the extreme dry year in particular, Table 6 and 7 highlight that zero flows can occur each month of the year but this does not necessarily mean that zero flows persist for the whole year.

**Table 6:** Streamflows (ML/d) for the Loddon River at Serpentine Weir (1976–2010).

| Month | Extreme dry year (minimum on record) | Dry year (30th percentile daily flow) | Median year (50th percentile daily flow) | Wet year (70th percentile daily flow) |
|---|---|---|---|---|
| Jul | 0 | 20 | 51 | 161 |
| Aug | 0 | 30 | 106 | 411 |
| Sep | 0 | 53 | 186 | 501 |
| Oct | 0 | 42 | 176 | 492 |
| Nov | 0 | 32 | 121 | 270 |
| Dec | 0 | 30 | 90 | 237 |
| Jan | 0 | 37 | 131 | 288 |
| Feb | 0 | 41 | 236 | 505 |
| Mar | 0 | 45 | 625 | 861 |
| Apr | 0 | 48 | 205 | 500 |
| May | 0 | 22 | 66 | 149 |
| Jun | 0 | 18 | 45 | 70 |

**Table 7:** Streamflows (ML/d) for the Loddon River downstream of Loddon Weir (1976–2010).

| Month | Extreme dry year (minimum on record) | Dry year (30th percentile daily flow) | Median year (50th percentile daily flow) | Wet year (70th percentile daily flow) |
|---|---|---|---|---|
| Jul | 0 | 7 | 12 | 67 |
| Aug | 0 | 7 | 14 | 133 |
| Sep | 0 | 7 | 11 | 214 |
| Oct | 0 | 7 | 10 | 46 |
| Nov | 0 | 6 | 9 | 13 |
| Dec | 0 | 5 | 7 | 12 |
| Jan | 0 | 5 | 7 | 11 |
| Feb | 0 | 6 | 8 | 12 |
| Mar | 0 | 6 | 8 | 12 |
| Apr | 0 | 6 | 8 | 11 |
| May | 0 | 7 | 9 | 30 |
| Jun | 0 | 7 | 13 | 39 |

## 4.2 Environmental water demands

### 4.2.1 Loddon River from Loddon Weir to Kerang Weir (Reach 4)

Section 3 of this document outlines that the aim for delivering water in the Loddon River is to provide a bankfull flow of 3,500 ML/d for six days in spring, in Reach 4. This should occur three to five times per decade. After this flow component has been provided, a winter baseflow of 100 ML/d can be delivered, provided it can be delivered in more than 80 per cent of years. When these winter baseflows are reliably provided, a spring fresh of 750 ML/d for 10 days every year (except bankfull flow years) can be delivered.

The volume required to deliver this bankfull event depends on unregulated flows in the river and the ability to enhance a natural flood event. SKM (2010) reports that flows above 3,500 ML/d in spring have occurred with a frequency of around 70 events per 100 years and flows above 750 ML/d in spring occur, on average, once per year (although in some years multiple events occur while in other years no events may occur). The range of volumetric requirements at the delivery site is shown in Table 8 for each desired event.

For the bankfull flow downstream of Loddon Weir, up to 19,300 ML would be required to extend historical events above the flow threshold to the desired event duration. Daily shortfalls in providing this event to the desired duration would have ranged up to 3,382 ML/d.

For the spring fresh event downstream of Loddon Weir up to 6,500 ML would be required to extend historical events above the flow threshold to the desired event duration. Daily shortfalls in providing this event to the desired duration would have ranged up to 730 ML/d.

For the winter baseflow following the bankfull flow of the previous year, part of the baseflow will already be provided under the Loddon River bulk entitlement. If the volume in the Loddon headworks storages is greater than 60,000 ML, then 61 ML/d is provided in this Reach. If the volume in storage is less than 60,000 ML, then 20 ML/d is provided in this Reach. That is, of the required flow of 18,200 ML over the six month winter period (May to October), a minimum of 3,600 ML would be provided under the bulk entitlement if the Loddon storages are below 60,000 ML and a minimum of 11,100 ML would be provided if they are above 60,000 ML. Natural runoff events will also provide some periods of baseflow above the target 100 ML/d. Taking these factors into account, it is estimated that in any given year, the volume required to address the shortfall on this target baseflow volume could range from 1,200 ML to 14,700 ML. These volumes are specified at the delivery site and exclude river losses, which can be as high as 40 per cent of the released volume, as discussed further in section 6.2.1.

**Table 8:** Range of event volumes required at the delivery site to achieve desired environmental flows in Reach 4.

| Desired flow event | Event volume required to piggyback natural events | | | |
|---|---|---|---|---|
| | Extreme dry | Dry | Median | Wet |
| Bankfull flow of 3,500 ML/d for 6 days in Loddon R d/s Loddon Weir | 0–19,300 ML | | 0–18,900 ML | |
| Winter baseflow of 100 ML/d(1) | 2,200–14,700 ML | | 1,200–7,200 ML | |
| Spring fresh of 750 ML/d for 10 days in Loddon R d/s Loddon Weir | n/a | 0–6,500 ML | 0–5,900 ML | |

n/a indicates that event is not expected to be provided under these climate conditions.

(1) extreme dry and dry conditions assume Loddon storages drop below 60,000 ML in the winter following the bankfull flow event (which triggers a reduction in minimum flows under the bulk entitlement) and therefore represent an upper bound demand that would be lower if storages remain above 60,000 ML.

### 4.2.2 Boort wetlands

The volumes required to either fill or top up the Boort wetlands at the delivery site is presented in Table 5 (section 3.3).

# 5. Operating regimes

## 5.1 Introduction

This section presents suggested operational triggers for implementation of the environmental flow proposals. These triggers should be used as a guide and refined based on operational experience after watering events. Operational water delivery includes several steps including:

- Identifying the target environmental flow recommendations for the coming season.
- Defining triggers to commence and cease delivering those recommended flows.
- Identifying any constraints on water delivery, such as available airspace in irrigation channels, the potential for flooding of private land, delivery costs, limits on releases from flow regulating structures and interactions with other environmental assets.

## 5.2 Identifying target environmental flow recommendations

The selection of target environmental flow recommendations in each of the different climate years is triggered by storage volume in the Loddon headworks storages (Cairn Curran Reservoir, Tullaroop Reservoir and Laanecoorie Reservoir) as shown in Table 9. This trigger is based on the Loddon River environmental flow triggers in Loddon River (Environmental Reserve) Bulk Entitlement (BE) Order 2005 (as amended).

**Table 9:** Identifying seasonal target environmental flow recommendations.

| Climate year for selecting flow recommendations | Storage volume in Loddon headworks storages | Events provided in preceding year |
|---|---|---|
| Extreme dry | Less than or equal to 60,000 ML[1] | None |
| Dry | | Bankfull |
| Medium | Greater than 60,000 ML[2] | N/a |
| Wet | | N/a |

(1) the target flow recommendations for extreme dry and dry years differ slightly. The target flow recommendations for dry years incorporate an additional spring fresh requirement (of 750 ML/d). The provision of this requirement is dependent on flow provisions in the preceding year. If flow provisions in the preceding year permit, the dry year objectives should be targeted, otherwise the extreme dry year objectives should be targeted.

(2) the target flow recommendations for medium and wet years are the same.

## 5.3 Delivery triggers

Proposed operational triggers for delivering the suggested environmental flow proposals are presented in Table 10.

The 3,500 ML/d bankfull event is the first target flow to reset the ecosystem. No other flow proposals are provided unless this bankfull event has occurred. The ability to deliver this event using environmental entitlements is limited by the outlet capacity of upstream storages and the Waranga Western Channel (discussed further in sections 5.4 and 5.5). Any contribution from environmental water entitlements to the bankfull event will be triggered by a naturally occurring event above that flow threshold. The travel time from Laanecoorie Reservoir to downstream of Loddon Weir, where the proposal is suggested, is approximately two to three days (see Section 5.7). This means that by monitoring flows downstream of Loddon Weir, there would be sufficient time to extend a naturally occurring event to the desired six day duration if the monitored flow is expected to remain above 3,500 ML/d for at least two to three days and environmental water managers are only planning to extend the event by a short duration. The circumstances under which a contribution from environmental water holdings could be made would be if:

(i) Cairn Curran Reservoir is spilling but Tullaroop Reservoir is not or vice versa, in which case releases from the reservoir below capacity can be timed to match or augment the flood peak from the spilling reservoir.

(ii) Cairn Curran and Tullaroop Reservoirs are below capacity and a flood peak is generated from unregulated tributaries upstream of Laanecoorie Reservoir, such as from Bet Bet Creek or McCallum Creek. Releases can be made from either reservoir to match or augment the flood peak from these tributaries.

(iii) A flood peak is generated on tributaries downstream of Laanecoorie Reservoir and releases from Laanecoorie Reservoir can help to extend the duration of the flood.

(iv) Waranga Western Channel deliveries are used to augment a flow peak as it passes through Loddon Weir, regardless of its origin.

The delivery of the 100 ML/d baseflow proposal in all years occurs continuously over the season specified in the flow proposals. This flow is within channel and can be delivered from the Loddon headworks storages. This flow can also be delivered to Reach 4 via the Waranga Western Channel if sufficient water is not available from the Loddon headworks storages. The delivery of this baseflow proposal shall only occur if the proposed bankfull event (3,500 ML/d) can be reliably provided in the near future or has already been provided recently (approximately within two to three years).

The delivery of the 750 ML/d spring fresh is dependent on conditions in the river in the preceding winter/spring period. This event shall only be delivered if both the baseflow (100 ML/d) and bankfull flow (3,500 ML/d) have been provided, in full, in the preceding year. If suitable conditions occurred in the preceding year, the spring fresh could be delivered to extend naturally occurring events. If an event has not commenced by the end of October, an event can be created. This flow is within channel and can be delivered via the Loddon River. Additional flow can also be delivered via the Waranga Western Channel to supplement this proposal if sufficient water is not available on the Loddon system. The ability to deliver this event using Goulburn and Campaspe system entitlements is limited by the outlet capacity of the Waranga Western Channel and is discussed further in section 5.5.

**Table 10:** Summary of proposed operational regime for achievement of environmental objectives.

| Climate year | Flow objective in Loddon River (Reach 4) | Season/ Timing | Average return period | Trigger for delivery | Trigger for ceasing delivery |
|---|---|---|---|---|---|
| Extreme dry | 100 ML/d | May–Oct | All extreme dry years. | Maintain throughout season. | n/a. |
| | 3,500 ML/d for 6 days | Aug–Nov | | • Commence delivery from Loddon headworks to augment naturally occurring bankfull event if natural duration is expected to be less than 6 days at d/s Loddon Weir.<br>• Augment delivery with water from the Waranga Western Channel. | n/a. |
| Dry, Medium and Wet | 100 ML/d | May–Oct | All dry, medium and wet years. | Maintain throughout season | n/a. |
| | 750 ML/d for 10 days | Aug–Nov | | • Commence delivery from Loddon headworks to augment naturally occurring event if natural duration is expected to be less than 10 days at d/s Loddon Weir.<br>• Augment delivery with water from the Waranga Western Channel as required.<br>• Deliver full event by 31 October.<br>Whichever occurs earliest.<br><br>Only deliver if both baseflow (100 ML/d) and winter/spring bankfull (3,500 ML/d) were provided in full in the preceding year. | n/a. |
| | 3,500 ML/d for 6 days | Aug–Nov | | • Commence delivery from Loddon headworks to augment naturally occurring bankfull event if natural duration is expected to be less than 6 days at d/s Loddon Weir.<br>• Augment delivery with water from the Waranga Western Channel. | n/a. |

# 5.4 Storage releases

The delivery of environmental water from storages may be constrained by the following storage release capacities:

### *Tullaroop Creek*

- The release capacity of Tullaroop Reservoir is 450 ML/d when below full supply level. This may constrain deliveries to Tullaroop Creek below Tullaroop Reservoir.

### *Loddon River downstream of Cairn Curran Reservoir*

- The release capacity of Cairn Curran Reservoir is 1,600 ML/d when below full supply level. This may constrain the ability to deliver high and overbank flows to the Loddon River downstream of Cairn Curran Reservoir.
- Note that water can be released from the spillway gates once storage in the reservoir exceeds 30 per cent of capacity. Release capacity is approximately 35,000 ML/d when the reservoir is at 40 per cent capacity and approximately 140,000 ML/d when the reservoir is at 100 per cent capacity (the flooding impacts of such release rates need to be considered, see Section 5.8).

*Loddon River downstream of Laanecoorie Reservoir*

- The release capacity of Laanecoorie Reservoir is 1,300 ML/d for regulated supply. This may constrain the ability to deliver high and overbank flows to the Loddon River downstream of Laanecoorie Reservoir.
- High flow rates released from Cairn Curran (such as high flows released through the spillway gates) will flow over the Laanecoorie Reservoir spillway.

## 5.5 Channel capacity

Waranga Western Channel capacity constraints can occur seasonally. The channel does not operate from mid-May to mid-August. During this time, Goulburn-Murray Water (G-MW) undertakes maintenance. Historically, the channel operates every second winter to supply the Wimmera-Mallee channel system, however with pipelining this will no longer be required. Approximate spare delivery capacities (ML/d) in the reach of the Waranga Western Channel upstream of the Loddon River are shown in Figure 3. Other reaches of the channel can also be constrained, particularly between Waranga Basin and the Campaspe siphon, however this reach is considered indicative of constraints between the Campaspe siphon and Loddon Weir. The data in Figure 3 is shown as a range of spare channel capacity over a range of allocations around the defined climate years.

This figure highlights, for example, that in an extreme dry year there can be in the order of 100–450 ML/d spare capacity in the channel, with the channel potentially operating at full capacity in spring. In a wet year it is possible that the channel will operate at full capacity throughout the irrigation season. Access to spare capacity in the channel is likely to be more limited in dry and median years than in extreme dry and wet years.

It should be noted that the irrigation demand pattern has changed significantly in recent (drought) years and the long term future pattern is unclear. This is not reflected in past analysis underpinning Figure 3. Hence the use of the Waranga Western Channel is an uncertain delivery path. G-MW should be consulted if the Waranga Western Channel is to be used to deliver environmental water, to check the likelihood of spare capacity in the channel at any given time.

Local capacity constraints within the irrigation channel system west of the Loddon River can also be a constraint to the delivery of water to the Boort wetlands. Delivery of water to the Boort wetlands via the channel system should be discussed in advance with G-MW to determine potential delivery times.

If environmental water managers want to use the channel system during the non-irrigation season, they need to consult with G-MW well in advance of the end of the irrigation season to determine whether deliveries via the channel system can be maintained during the non-irrigation season. To use this option, casual user charges apply, as well as operational loss (of water) associated with running the channel from its own entitlement.

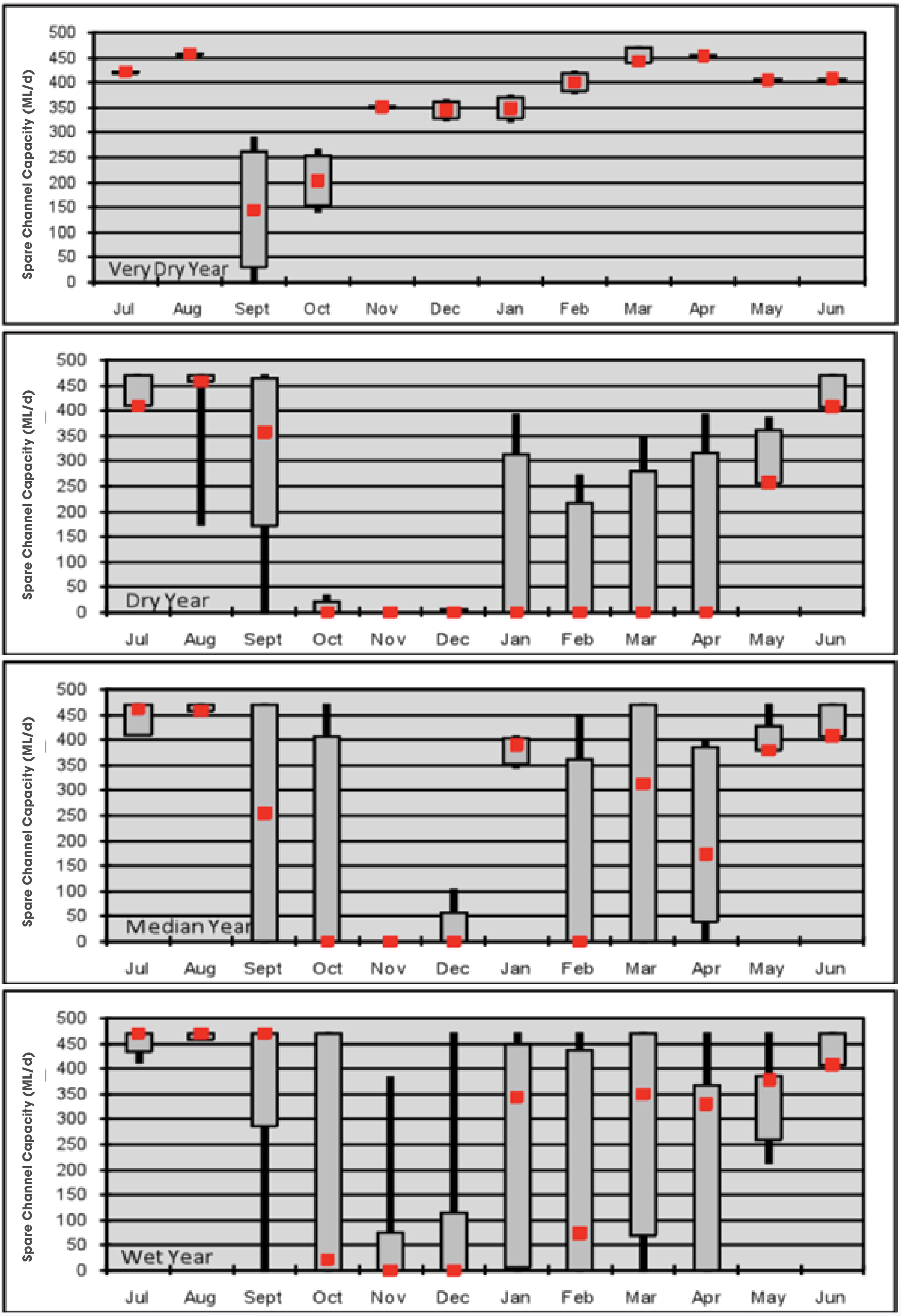


**Figure 3:** Spare channel capacity in the Waranga Western Channel upstream of Loddon Weir, 1895–2009.

## 5.6 Weir flow control

The delivery of low environmental flow recommendations (such as summer low flows) can be limited by the ability of weirs, particularly Bridgewater Weir and Kerang Weir, to regulate low flows (SKM 2006). Further details of reliably regulated flow thresholds were not presented in SKM (2006).

Low flow control at Serpentine Weir has traditionally been limited; however, a small, remotely-operated door system has recently been fitted to improve flow control at low rates.

## 5.7 Travel time

Two runoff events in October and November of 2000 were analysed to gain an appreciation of travel times along the Loddon River. For these events, which peaked at 3,000 – 5,000 ML/d downstream of Serpentine Weir, travel time was in the order of two to three days from Laanecoorie Reservoir to Loddon Weir, with a further six day travel time from Loddon Weir to Appin South. By the time the flood event had passed through Kerang Weir pool, it was unrecognisable as a flood peak due to attenuation and mixing with regulated flows from Pyramid Creek. This is shown in Appendix 1.

For deliveries using the channel system, G-MW requires an order four days in advance to guarantee the delivery (although order times are expected to decrease with modernisation). The implication is that if a runoff event occurs in the Loddon River, there is a limit to the operational flexibility to order additional water from the Goulburn and Campaspe systems to supplement the natural event. This is because the travel time along the Goulburn/Campaspe Rivers and then along Waranga Western Channel is longer than the travel time along the Loddon River from Laanecoorie Reservoir to Loddon Weir. However, if a rainfall event occurs, orders for water are likely to be cancelled and water in transit in the channel system plus water in balancing storages such as Tandarra pondage may be able to be called upon. This would allow environmental water managers to use Waranga Western Channel water from the Goulburn and Campaspe systems for long duration events where four day forecasts indicate the likely need for top-up of the natural flow event from the channel system.

## 5.8 Flooding

River channel capacities are generally not a constraint to delivering the proposed environmental flows. The thresholds for significant flooding at key locations are summarised in Table 11. These thresholds are in excess of the proposed environmental flows at these sites.

**Table 11:** Thresholds for significant flooding (SKM 2006).

| Location | Threshold for Significant Flooding |
|---|---|
| Tullaroop Creek below Tullaroop Reservoir | 5,000 ML/d (bankfull capacity) |
| Loddon River downstream of Cairn Curran Reservoir | 21,000 ML/d |
| Loddon River downstream of Serpentine Weir | 10,000 ML/d – breakout towards Butchers Lagoon |
| Loddon River downstream of Loddon Weir | 5,000 ML/d – breakout towards Kelshes Lagoon |
| Loddon River downstream of Kerang Weir | 4,000 ML/d |

Whilst river channel capacities are generally not a constraint to delivering the proposed environmental flows, between Loddon Weir and Kerang Weir higher flows break out of the main river channel into a series of anabranches and distributary channels. The capacity of the main river channel decreases significantly to approximately 300 ML/d downstream of The Chute. This means that the proposed spring fresh for Reach 4 (750 ML/d) would be expected to engage the distributary channel system. Figure 4 shows the location of key features and distributary channels of the lower Loddon River.

The largest of these distributary channels are:

- Kinypanial Creek.
- Venables Creek.
- Twelve Mile Creek.
- Wandella Creek.

The commence-to-flow thresholds of these distributary channels are uncertain due to regular changes in channel morphology and the complexity of the channel system. Additionally, water loss along this reach of the river is believed to be high, particularly during dry conditions, however the magnitude of loss is uncertain. Further investigations are required to determine likely flow paths and loss at different delivery rates through this reach of the Loddon River.

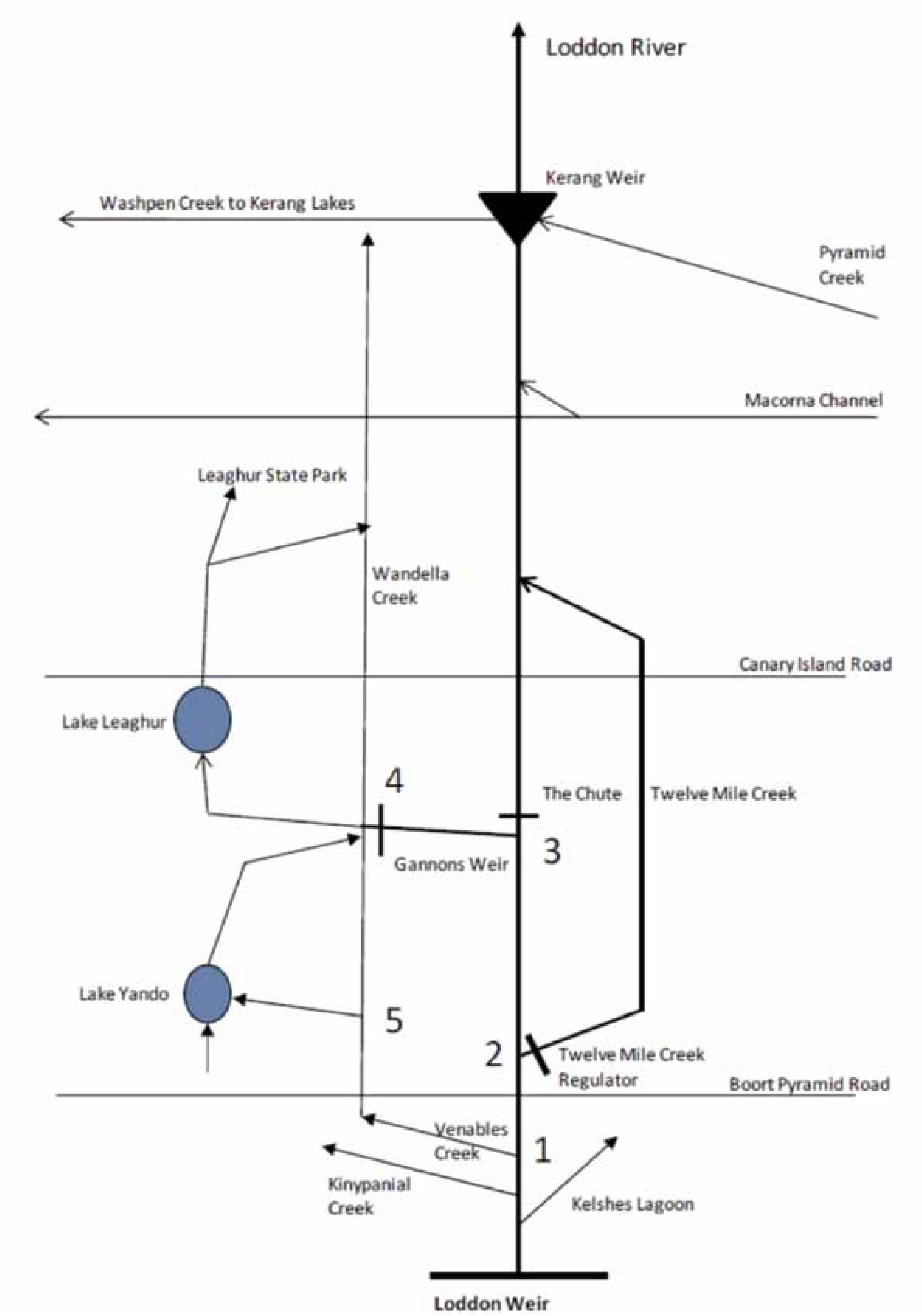


**Figure 4:** A schematic diagram showing the location of key features and distributary channels of the lower Loddon River (SKM 2010).

## 5.9 Water delivery costs

### 5.9.1 Delivery costs

There are no delivery costs if water is delivered via the river system. However, any water delivered via the Waranga Western Channel from the Goulburn or Campaspe systems would attract additional fees.

If water for Boort district wetlands is ordered from the Waranga Western Channel system, then the following charges apply in 2011–12: $200 per service point plus $7.85 per ML. This information can be found on G-MW's website http://www.g-mwater.com.au/customer-services/feesandcharges. Note that delivery and storage charges are subject to review on an annual basis.

### 5.9.2 Carryover costs

G-MW charges per megalitre for water share transferred from the spillable water account to an allocation bank account for the Goulburn, Campaspe and Murray systems. These charges do not currently apply to the Loddon system (where spillable water accounts are not available).

## 5.10 Interactions with other assets

The Loddon River system is hydraulically connected to the Kerang Lakes system and the Murray River system (discharging to the Murray River system downstream of Torrumbarry Weir). Water can be delivered to these hydraulically connected assets via the Loddon River, however, high losses along the lower Loddon River between Loddon Weir and Kerang Weir, particularly at high flows, limits this opportunity.

Entitlements held in the Goulburn and Campaspe systems can also be used to deliver water to the Loddon River downstream of Loddon Weir.

# 6. Governance and planning arrangements

## 6.1 Delivery partners, roles and responsibilities

The major strategic partners in delivering water to assets with the Loddon system include:

- Victorian Environmental Water Holder, is responsible for making decisions on the use of Victorian environmental water.
- North Central CMA, as the environmental water manager for the Loddon system.
- G-MW, as the BE holder and manager of the major reservoirs in the catchment, manager of the Pyramid-Boort Irrigation Area and also the licensing authority responsible for groundwater and surface water licensed diversions.

Both the North Central CMA and G-MW cooperate with the GB CMA and the VEWH in the delivery of environmental water, particularly in relation to water transfers from the Goulburn and Campaspe systems.

## 6.2 Approvals, licenses, legal and administrative issues

### 6.2.1 Water shepherding and return flows

In Victoria, the policy position presented in the *Northern Region Sustainable Water Strategy* is to allow all entitlement holders to reuse or trade their return flows downstream provided that:

- There is adequate rigour in the calculation and/or measurement of return flows.
- The return flows meet relevant water quality standards.
- Additional losses (if any) are taken into account.
- The return flows can be delivered in line with the timing requirements of the downstream user, purchaser or environmental site.
- The system operator can re-regulate the return flows downstream, with a known and immaterial spill risk, if the entitlement holder is requesting credits on a regulated system (DSE 2009).

The Commonwealth Government does not currently have the ability to deliver water from its water shares for the Loddon system, so it must transfer its allocations to the VEWH for them to be used. If the Commonwealth Government transfers its allocations to the environmental entitlements held by the VEWH then the ability to reuse those flows in the Murray River depends on the conditions of the individual entitlements.

Gaining credits in the Torrumbarry system for water delivered down the Loddon River could be difficult as losses in the Loddon River downstream of Loddon Weir are very high with numerous distributaries heading both east and west from the river channel. Flow gauging accuracy is low at high flows in this area, which further compounds uncertainty in estimating losses. DSE has estimated losses in its monthly GSM REALM model using gauged flows along the Loddon River. This loss is both high and very uncertain. Losses between Loddon Weir and Appin South (approximately half way along Reach 4) is defined in a function contained in Schedule 2 of the environmental entitlement for the Loddon River, and is capped at 40 per cent of the flow immediately downstream of Loddon Weir. Losses downstream of Appin South (to Kerang Weir) and losses along the distributary systems are not well understood.

If water is delivered from the Loddon headworks, it can only be delivered in the regulated river section of the Loddon River, which ends at the Loddon Weir pool. Downstream of the Loddon Weir pool is a different trading zone and flows are considered unregulated. According to G-MW (A. Shields, G-MW, pers. comm. 1/12/10), water ordered from the Loddon headworks storages can be delivered via the Loddon River to an ordering point immediately downstream of Loddon Weir. Beyond this point, the water cannot be shepherded through to Kerang Weir as private diverters can access the water (see also section 7).

If the water shares held in the Loddon headworks storages are used to augment winter low flows, spring fresh and bankfull events in the Loddon River, it is likely that demands from private diverters downstream of Loddon Weir will be low. This means that any flow events upstream of Loddon Weir that environmental water has contributed to are likely to pass downstream without being diverted by consumptive users. The exception to this will be in the first fresh or winter low flow after a dry autumn and winter, when private diverters will want to refill their dams. Environmental water managers should liaise further with G-MW to better understand any potential shepherding of environmental flows along this reach in the future.

## 6.3 Trading rules and system accounting

### 6.3.1 Water trading

Victorian and southern NSW water trading zones are shown in Figure 5 and Table 12 summarises trading capabilities between zones.

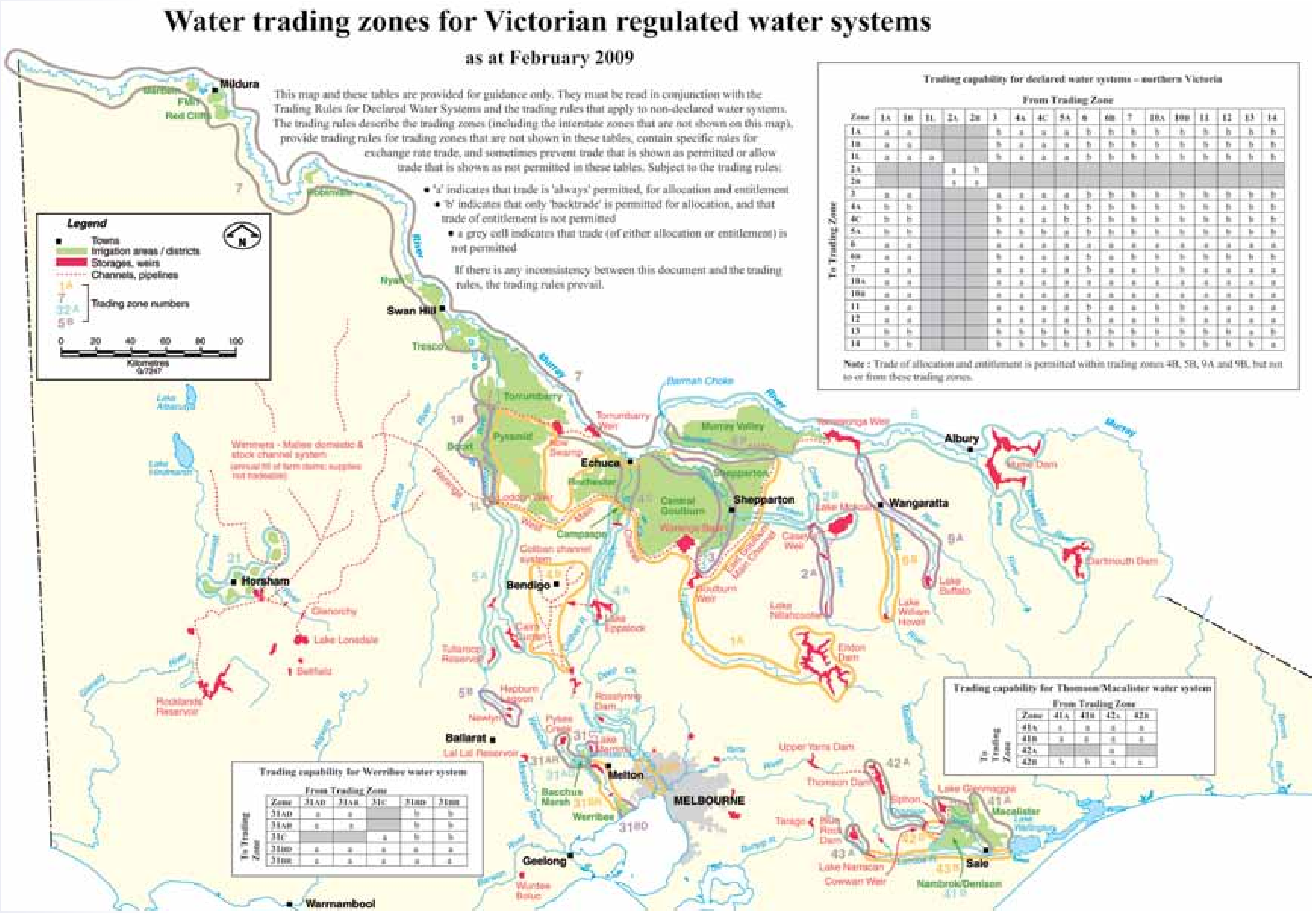


**Figure 5:** Victorian and southern NSW water trading zones and trading capability (Source: http://waterregister.vic.gov.au/Public/Documents/trading_zones_map.pdf).

The Loddon River system down to but not including Loddon Weir is located in Trading Zone 5A, the Loddon Weir pool is located in Trading Zone 1L and the Loddon River between Loddon Weir and Kerang Weir is located in Trading Zone 1B.

## **Table 12:** Summary of trading rules between zone

| | | From trading zone: | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Zones | 1A Greater Goulburn | 1B Boort | 1L Loddon Weir Pool | 3 Lower Goulburn | 4A Campaspe | 4C Lower Campaspe | 5A Loddon | 6 Vic. Murray: Dartmouth - Barmah | 6B Lower Broken Creek | 7 Vic. Murray: Barmah to S.A. | 10A NSW Murray above Barmah | 10B Murray Irrigation Limited | 11 NSW Murray below Barmah | 12 South Australian Murray | 13 Murrumbidgee | 14 Lower Darling |
| Into trading zone: 1A | Greater Goulburn | ■ | ■ | | □ | ■ | ■ | ■ | □ | □ | □ | □ | □ | □ | □ | □ | □ |
| 1B | Boort | ■ | ■ | | □ | ■ | ■ | ■ | □ | □ | □ | □ | □ | □ | □ | □ | □ |
| 1L | Loddon Weir Pool | ■ | ■ | ■ | □ | ■ | ■ | ■ | □ | □ | □ | □ | □ | □ | □ | □ | □ |
| 3 | Lower Goulburn | ■ | ■ | | ■ | ■ | ■ | ■ | □ | □ | □ | □ | □ | □ | □ | □ | □ |
| 4A | Campaspe | □ | □ | | □ | ■ | ■ | □ | □ | □ | □ | □ | □ | □ | □ | □ | □ |
| 4C | Lower Campaspe | □ | □ | | □ | ■ | ■ | □ | □ | □ | □ | □ | □ | □ | □ | □ | □ |
| 5A | Loddon | □ | □ | | □ | □ | □ | ■ | □ | □ | □ | □ | □ | □ | □ | □ | □ |
| 6 | Vic. Murray -Dartmouth to Barmah | ■ | ■ | | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ |
| 6B | Lower Broken Creek | ■ | ■ | | □ | ■ | ■ | ■ | □ | ■ | □ | □ | □ | □ | □ | □ | □ |
| 7 | Vic. Murray – Barmah to South Australia | ■ | ■ | | ■ | ■ | ■ | ■ | □ | ■ | ■ | □ | □ | ■ | ■ | ■ | ■ |
| 10A | NSW Murray above Barmah | ■ | ■ | | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ |
| 10B | Murray Irrigation Limited | ■ | ■ | | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ |
| 11 | NSW Murray below Barmah | ■ | ■ | | ■ | ■ | ■ | ■ | □ | ■ | ■ | □ | □ | ■ | ■ | ■ | ■ |
| 12 | South Australian Murray | ■ | ■ | | ■ | ■ | ■ | ■ | □ | ■ | ■ | □ | □ | ■ | ■ | ■ | ■ |
| 13 | Murrumbidgee | □ | □ | | □ | □ | □ | □ | □ | □ | □ | □ | □ | □ | □ | ■ | □ |
| 14 | Lower Darling | □ | □ | | □ | □ | □ | □ | □ | □ | □ | □ | □ | □ | □ | □ | ■ |

■ Entitlement and allocation trade
□ Allocation (no entitlement) trade up to the volume of back-trade to date

### *Additional Trading Rules*

All trade, except to unregulated tributaries, is with an exchange rate of 1.00. Trade into the unregulated river zones of the Loddon (zones 150 and 151) can only be transferred as a winterfill licence, which becomes available in the following year. The water share volume is increased by 19 per cent when transferred to a winterfill licence, and decreased by 19 per cent when bought from a winterfill licence. Trading into Murray Irrigation Limited areas (zone 10B) attracts a 10 per cent loss of share volume.

Permanent trade is currently limited to 4 per cent per year from irrigation districts in Victoria. G-MW advises via media releases when these limits are reached for individual irrigation districts. There are various exemptions for this limit specified in the trading rules on the Victorian Water Register (http://waterregister.vic.gov.au/).

A service standard for allocation trade processing times has been implemented by the Council of Australian Governments (COAG):

- Interstate – 90 per cent of allocation trades between NSW/Victoria processed within 10 business days.
- Interstate – 90 per cent of allocation trades to/from South Australia processed within 20 business days.
- Intrastate – 90 per cent of allocation trades processed within five business days.

This means that environmental water managers must make any allocation trades well in advance of a targeted runoff event.

Water trading attracts water trading fees. If water trading is undertaken without the use of a broker, the fees are currently less than $80 for a Victorian intrastate State trade. See the Victorian Water Register for Victorian fee schedules at http://www.waterregister.vic.gov.au/Public/ApplicationFees.aspx.

## 6.3.2 Water storage accounting

Water storage accounting for the Loddon system is annual water accounting (July to June) with limited carryover.

Carryover on the Loddon System is limited to a maximum volume of 50 per cent of the water holder's high-reliability water shares and 50 per cent of the water holders low reliability water shares (note that unused allocation is carried over against high reliability water shares first). On 1 July each year, 5 per cent is deducted from the carryover volume for evaporation loss.

The maximum volume that can be held in a water holder's allocation bank account is 100 per cent of their entitlement. This means that if a water holder carries over 50 per cent against their high-reliability water shares at the start of the season (July 1), the water holder's allocation bank account will hold 47.5 per cent (50 per cent carryover less (5 per cent x 50 per cent carryover volume) for evaporation). Once the current season allocations reach 52.5 per cent (i.e. total water holdings reach 100 per cent), no further allocation improvements will be credited to the allocation bank account, regardless of whether the account is drawn down in the current year. Therefore, carrying over water will only be of value if next season's allocations are expected to be less than 100 per cent, or if early season allocations are expected to be low and environmental watering is required.

Please note that carryover arrangements on the Loddon River system are currently under review by DSE.

More information on carryover can be accessed at http://www.g-mwater.com.au/customer-services/carryover/lbbcarryover/.

# 7. Risk assessment and mitigation

Risks associated with the delivery of environmental water to both the Loddon River and Boort wetlands are summarised in Table 13 and Table 14. It should be noted that risks are not static and require continual assessment to be appropriately managed. Changes in conditions will affect the type of risks, the severity of their impacts and the mitigation strategies that are appropriate for use. As such, a risk assessment must be undertaken prior to the commencement of water delivery. A framework for assessing risks has been developed by SEWPaC and is included at Appendix 6.

**Table 13:** Risk associated with water delivery in the Loddon system.

| Risk type | Description | Likelihood | Consequence | Risk level | Controls |
|---|---|---|---|---|---|
| Acid sulfate soils | Acid sulfate soils suspected in Reach 4 of the Loddon River. | Possible, depending on rainfall received. Greater likelihood in drier conditions with lower river levels. | Major | Medium | Do not operate this reach unless a large flow event occurs in winter-spring. |
| Salinity | Water salinity in the Loddon River can exceed 1,500 EC, which is a threshold often used to indicate increased risk to aquatic organisms. The extent to which additional releases contribute to or exacerbate salinity problems should be considered as releases from the Loddon storages are contemplated. Releases from the Goulburn via Waranga Western Channel are of good quality and are unlikely to pose a salinity risk at the volumes proposed. | Possible | Minor | Low | Monitor salinity of water delivered to the assets. Seek alternative sources of water should water quality be deemed to increase risks associated with salinity. |
| Blackwater | Blackwater events have been recorded with the release of water after prolonged dry or low flow periods in Reach 4. | Unlikely – Likely, depending on antecedent conditions. | Moderate | Medium | Ensure flow releases are of sufficient magnitude and duration to avoid blackwater after periods of low or no flow. Also ensure routine flows to prevent litter build-up. |
| River red gum incursion | Wetting and drying of the river channel (e.g. in Reach 4) provides conditions that may favour the incursion of river red gum. Over time, the growth of trees can alter the hydraulics and geomorphology of the channel. | Likely | Moderate | Medium | Survey river red gum saplings that have survived recent (2010) floods. Review the need to implement physical (or other) control mechanisms. |
| Other considerations | Flooding of private land. | Possible | Minor | Low | Coincide releases with water delivered via Waranga Western Channel to avoid localised flooding below Cairn Curran.<br><br>Evaluate the potential for flooding of private land along Reach 4 with bankfull discharge. |

**Table 14:** Risk associated with water delivery in the Boort wetlands.

| Risk type | Description | Likelihood | Consequence | Risk level | Controls |
|---|---|---|---|---|---|
| Acid sulfate soils | No known issues at wetland sites. | Unlikely | Major | Medium | Survey wetlands during dry phase to find any evidence of ASS. |
| Salinity | Water salinity levels in the environmental water provided from the Loddon River (particularly during times of drought) or Waranga Western Channel for the Boort wetlands could pose a risk to salinity levels at these assets:<br>• The extent to which additional releases contribute to or exacerbate salinity problems should be considered at the time that releases from the Loddon storages are contemplated.<br>• Releases from the Goulburn via Waranga Western Channel are of good quality and are unlikely to pose a salinity risk at the volumes proposed. | Unlikely | Minor | Low | Monitor salinity of water delivered to the assets. |
| Invasive species | Carp and mosquito fish may invade with inflows. | Likely | Moderate | Medium | Install carp screens on inlet channels. |
| Blackwater | May occur when rewetting after prolonged dry period. | Unlikely – Likely, depending on antecedent conditions. | Moderate | Medium | Regular provision of environmental water will help to minimise the build up of organic matter.<br>Time deliveries to occur when temperatures are low. |
| Water loss | Water losses are likely when refilling dry wetlands. | Likely | Minor | Medium | Allow for losses when estimating allocations to individual sites. |
| Other considerations | Flooding of private land.<br>Risk of flooding in Reach 4 needs to be considered and managed. | Possible | Minor | Low | Plan delivery for times when there is capacity in the Western Waranga Channel and releases from Cairn Curran Resevoir are not to exceed 1600 ML/d. |

# 8. Environmental water reserves

## 8.1 Environmental water holdings and provisions

### 8.1.1 Water planning responsibilities

The Northern Region Sustainable Water Strategy (NRSWS) provides the strategic direction for water management across northern Victoria (DSE 2009). Responsibilities for the planning and delivery of water specified by the Loddon Bulk Entitlements are shared between G-MW and the North Central CMA, in collaboration with DSE and the VEWH.

Commonwealth environmental water in the Loddon system can be delivered from the Loddon headworks storages (Cairn Curran or Tullaroop Reservoirs). There is also the potential to deliver water shares in the Goulburn system to the lower Loddon system (downstream of Loddon Weir) via the Waranga Western Channel when spare capacity is available.

### 8.1.2 Environmental water provisions

Minimum passing flow requirements are specified in Schedule 1 to the Bulk Entitlement (Loddon River – Environmental Reserve) Order 2005 (as amended) and are summarised in Table 15. The minimum passing flow requirements must be provided first under Clause 10.1 of G-MW's entitlement.

**Table 15:** Minimum passing flow requirements in bulk entitlements for the Loddon River.

| Reach | Season | Requirements |
|---|---|---|
| Reach 1: Loddon River – Cairn Curran Dam to Laanecoorie Reservoir. | Nov – Apr | Minimum flow of 20 ML/d or natural*. |
| | Nov – Apr | Fresh flow of 35 ML/d for 7 consecutive days, 4 per season or natural. |
| | May – Oct | Minimum flow of 35 ML/d or natural if storage in Cairn Curran and Tullaroop Reservoirs is > 60,000 ML.<br><br>Minimum flow of 20 ML/d or natural if storage in Cairn Curran and Tullaroop Reservoirs is ≤ 60,000 ML. |
| Reach 2: Tullaroop Creek – Tullaroop Dam to Laanecoorie Reservoir. | All year | Minimum flow of 10 ML/d or natural. |
| | Nov – Apr | Fresh flow of 13.5 ML/d for 7 consecutive days, 4 per season or natural. |
| Reach 3a: Loddon River – Laanecoorie Reservoir to Serpentine Weir. | Nov – Jul | Minimum flow of 15 ML/d or natural. |
| | Aug – Oct | Minimum flow of 52 ML/d or natural if storage in Cairn Curran and Tullaroop Reservoirs is > 60,000 ML.<br><br>Minimum flow of 15 ML/d or natural if storage in Cairn Curran and Tullaroop Reservoirs is ≤ 60,000 ML. |
| | Nov – Apr | Fresh flow of 52 ML/d for 13 consecutive days, 3 per year or natural. |
| Reach 3b: Loddon River – Serpentine Weir to Loddon Weir. | Nov – Apr | Minimum flow of 19 ML/d or natural. |
| | May – Oct | Minimum flow of 61 ML/d or natural if storage in Cairn Curran and Tullaroop Reservoirs is > 60,000 ML.<br><br>Minimum flow of 19 ML/d or natural if storage in Cairn Curran and Tullaroop Reservoirs is ≤ 60,000 ML. |
| | Nov – Apr | Fresh flow of 61 ML/d for 11 consecutive days, 3 per season or natural. |
| Reach 4: Loddon River – Loddon Weir and Kerang Weir. | Nov – Apr | Minimum flow to be varied over a cyclical two week period; rising from 7 ML/d to 12 ML/d in the first week, falling from 12 ML/d to 7 ML/d in the second week (plus losses). |
| | May – Oct | Minimum flow of 61 ML/d (plus losses) if storage in Cairn Curran and Tullaroop Reservoirs is > 60,000 ML.<br><br>Minimum flow of 20 ML/d (plus losses) if storage in Cairn Curran and Tullaroop Reservoirs is ≤ 60,000 ML. |
| | Jan – Feb | Fresh flow of 40 ML/d (plus losses) for 14 consecutive days. |

*'or natural' refers to minimum flows (below the prescribed minimum flows) that would occur naturally, for example with low catchment inflows during dry periods. Allowing discharge to fall below the prescribed flow to what would occur naturally under dry conditions will help to retain part of the natural variability of the flow regime.

### 8.1.3 Current water holdings

Commonwealth environmental water holdings (as at October 2010) are summarised in Table 16. Note: Loddon water shares can be used in the Loddon River directly. Water shares from the Goulburn and Campaspe systems can only be used if sufficient channel capacity to deliver the entitlements is available in the Waranga Western Channel, as the Commonwealth environmental water holdings do not include delivery shares.

Volumes of Commonwealth environmental water are constantly being updated. For the latest figures see www.environment.gov.au/ewater.

**Table 16:** Commonwealth environmental water holdings (as at October 2010).

| System | Licence Volume (ML) | Water share type |
|---|---|---|
| NSW Murray above Barmah Choke | 0.0 | High security |
| | 155,752.0 | General security |
| VIC Murray above Barmah Choke | 32,361.3 | High reliability water share |
| | 5,674.1 | Low reliability water share |
| Ovens* | 0.0 | |
| **Total above Barmah Choke** | **32,361.3** | **High security/reliability** |
| | **161,426.1** | **Low security/reliability** |
| NSW Murray below Barmah Choke | 386.0 | High security |
| | 32,558.0 | General security |
| VIC Murray below Barmah Choke | 78,721.9 | High reliability water share |
| | 5,451.3 | Low reliability water share |
| Murrumbidgee*** | 64,959.0 | General security |
| | 0.0 | |
| Goulburn | 64,919.6 | High reliability water share |
| | 10,480.0 | Low reliability water share |
| Broken** | 0.0 | |
| | 0.0 | |
| Campaspe | 5,124.1 | High reliability water share |
| | 395.4 | Low reliability water share |
| Loddon | 1,179.0 | High reliability water share |
| | 527.3 | Low reliability water share |
| South Australia | 43,297.4 | High reliability |
| **Total below Barmah Choke** | **193,628.0** | **High security/reliability** |
| | **114,371.0** | **Low security/reliability** |

* Commonwealth environmental water includes 70.0 ML of regulated river entitlement on the Ovens System; however this water cannot be traded outside of the Ovens Basin.

** Commonwealth environmental water includes 20.0 ML of high reliability water share and 4.2 ML of low reliability water share on the Broken System; however this water cannot be traded outside of the Broken Basin.

*** The Commonwealth environmental water holdings include 20,820 ML of supplementary water shares on the Murrumbidgee System; however this water cannot be traded outside of Murrumbidgee system.

Environmental water currently held under Bulk Entitlements by the VEWH are summarised in Table 17.

**Table 17:** Environmental water currently held under Bulk Entitlements by the VEWH.

| Water holding | Volume | Specifications |
|---|---|---|
| Boort District Wetland Entitlement<br><br>Bulk Entitlement (Loddon River – Environmental Reserve) Order 2005. | 2,000 ML | High reliability water share.<br><br>Can be supplied to Lake Meran, Little Lake Meran, Lake Boort, Lake Yando, Lake Leaghur or other priority wetlands. |
| `Sales Package' (unbundling of prior water rights)<br><br>Bulk Entitlement (Loddon River – Environmental Reserve) Conversion Amendment Notice 2007. | 2,105 ML | Low reliability water share.<br><br>Non-specified environmental water. Can be used to deliver Loddon River environmental flows or to deliver water to the Boort district wetlands. |
| Wimmera-Mallee Pipeline Savings Entitlement<br><br>Bulk Entitlement (Loddon River – Environmental Reserve) Amendment Order October 2010. | 7,490 ML | Availability assessed on 1 July each year.<br><br>Available in full if Goulburn system allocation in April of the previous year was 1 per cent or greater.<br><br>0 ML available if Goulburn system allocation in April of the previous year was less than 1 per cent.<br><br>Only available for use downstream of Loddon Weir. |

## 8.2 Seasonal allocations

Loddon system seasonal allocation in Schedule 3 of G-MW's entitlement is a function of the Goulburn system allocation unless there is a local water shortage. Figure 6 and Figure 7 provide a summary of October and April seasonal allocations, indicative of spring and autumn water availability, for the Loddon, Goulburn and Campaspe systems respectively. This information is sourced from the MSM-Bigmod post-TLM run (#22061).

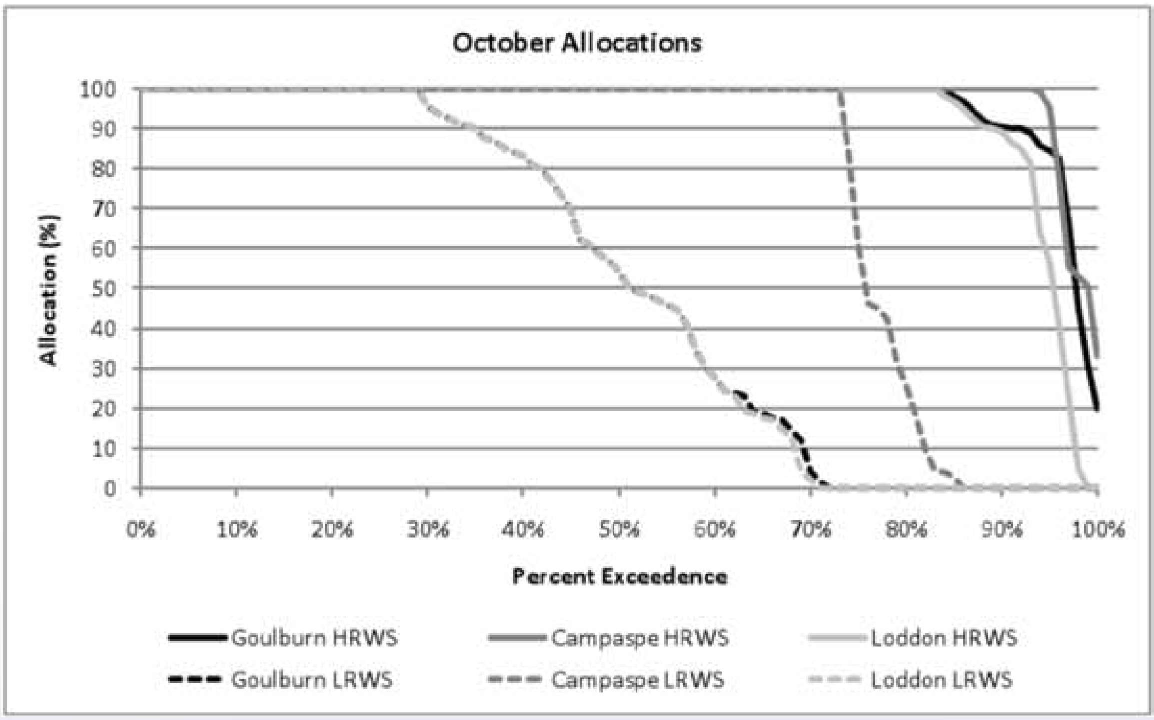


**Figure 6:** October seasonal allocations for the Loddon, Goulburn and Campaspe systems.

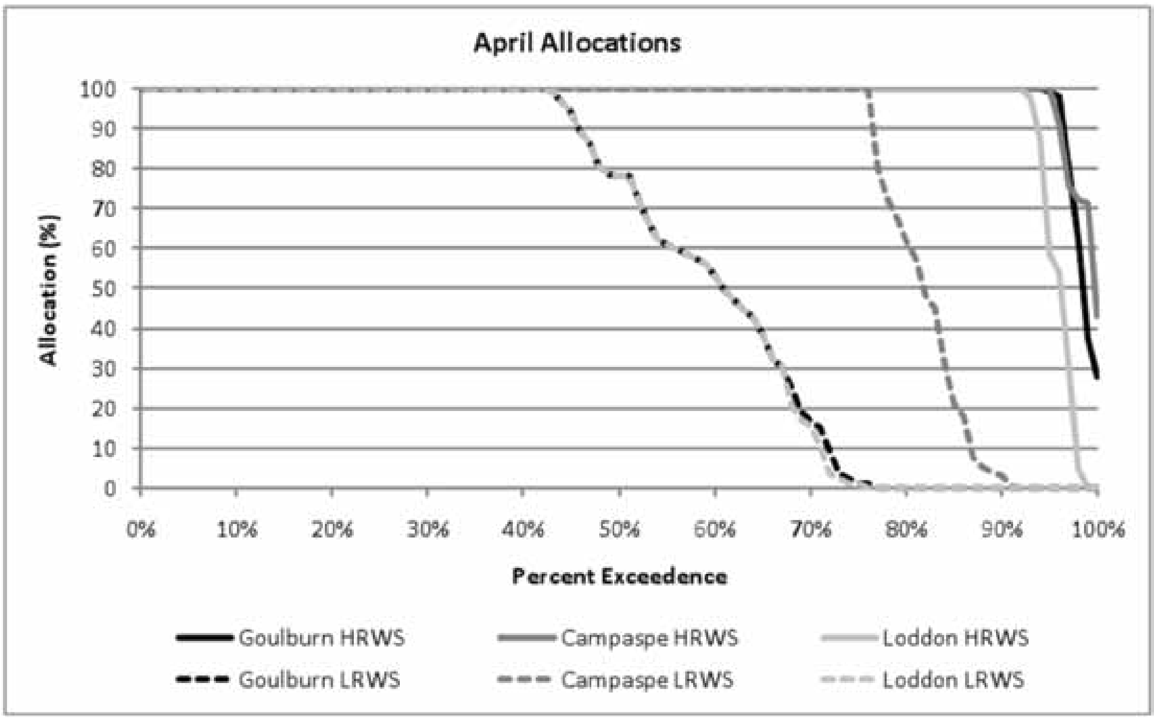


**Figure 7:** April seasonal allocations for the Loddon, Goulburn and Campaspe systems.

The allocation expected to be available (in terms of announced allocation) to the environment under different climate conditions is summarised in Table 18. The corresponding volume of water expected to be available to the environment under different climate conditions is summarised in Table 19.

The calculation of the volume of water expected to be available to the environment under each climate condition is based on the volume and type of entitlements held and the expected announced allocation for each climate scenario. Tables 18 and 19 were produced by SKM using allocation information from MSM-Bigmod with TLM deliveries in place (run #22061).

The tables show that no water is expected to be available in the Loddon system in an extreme dry year. It would be expected that in spring of a wet year there would be 100 per cent of high reliability water shares and 96 per cent of low reliability water shares (1,700 ML based on October 2010 holdings) available.

**Table 18:** Likely announced allocation under different climate scenarios.

| River System | Security | Registered Entitlements (ML) (Oct 2010) | Water Availability | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | October Allocation (%) | | | | April Allocation (%) | | | |
| | | | Very Dry | Dry | Median | Wet | Very Dry | Dry | Median | Wet |
| NSW Murray above Barmah Choke | General Security | 155,752.0 | 1 | 62 | 96 | 100 | 12 | 100 | 100 | 100 |
| Victorian Murray above Barmah Choke | High reliability water share | 32,361.3 | 9 | 100 | 100 | 100 | 29 | 100 | 100 | 100 |
| | Low reliability water share | 5,674.1 | 0 | 99 | 100 | 100 | 0 | 100 | 100 | 100 |
| Ovens | High reliability water share | 70.0 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 |
| NSW Murray below Barmah Choke | High security | 386.0 | 97 | 97 | 97 | 100 | 97 | 100 | 100 | 100 |
| | General Security | 32,558.0 | 1 | 62 | 96 | 100 | 12 | 100 | 100 | 100 |
| Victorian Murray below Barmah Choke | High reliability water share | 78,721.9 | 9 | 100 | 100 | 100 | 29 | 100 | 100 | 100 |
| | Low reliability water share | 5,451.3 | 0 | 99 | 100 | 100 | 0 | 100 | 100 | 100 |
| Murrumbidgee | General Security | 64,959.0 | 10 | 42 | 55 | 64 | 10 | 68 | 100 | 100 |
| | Supplementary | 20,820.0 | 0 | 0 | 0 | 100 | 0 | 0 | 0 | 100 |
| Goulburn | High reliability water share | 64,919.6 | 20 | 100 | 100 | 100 | 28 | 100 | 100 | 100 |
| | Low reliability water share | 10,480.0 | 0 | 4 | 54 | 96 | 0 | 17 | 78 | 100 |
| Broken | High reliability water share | 20.0 | 1 | 96 | 97 | 98 | 1 | 100 | 100 | 100 |
| | Low reliability water share | 4.2 | 0 | 0 | 0 | 0 | 0 | 100 | 100 | 100 |
| Campaspe | High reliability water share | 5,124.1 | 33 | 100 | 100 | 100 | 43 | 100 | 100 | 100 |
| | Low reliability water share | 395.4 | 0 | 100 | 100 | 100 | 0 | 100 | 100 | 100 |
| Loddon | High reliability water share | 1,179.0 | 0 | 100 | 100 | 100 | 0 | 100 | 100 | 100 |
| | Low reliability water share | 527.3 | 0 | 2 | 54 | 96 | 0 | 16 | 78 | 100 |
| South Australia | High reliability | 43,297.4 | 44 | 100 | 100 | 155 | 62 | 100 | 100 | 102 |

**Table 19:** Likely volume available to the environment from Commonwealth environmental water holdings (as at October 2010), under different climate scenarios.

| River System | Security | Registered Entitlements (ML) (Oct 2010) | Water Availability | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | October Allocation (GL) | | | | April Allocation (GL) | | | |
| | | | Very Dry | Dry | Median | Wet | Very Dry | Dry | Median | Wet |
| NSW Murray above Barmah Choke | General Security | 155,752.0 | 2.2 | 97.2 | 149.1 | 155.8 | 19.3 | 155.8 | 155.8 | 155.8 |
| Victorian Murray above Barmah Choke | High reliability water share | 32,361.3 | 2.9 | 32.4 | 32.4 | 32.4 | 9.4 | 32.4 | 32.4 | 32.4 |
| | Low reliability water share | 5,674.1 | 0.0 | 5.6 | 5.7 | 5.7 | 0.0 | 5.7 | 5.7 | 5.7 |
| Ovens* | High reliability water share | 70.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| **Total above Barmah Choke** | | | **5.1** | **135.2** | **187.2** | **193.8** | **28.7** | **193.8** | **193.8** | **193.8** |
| NSW Murray below Barmah Choke | High security | 386.0 | 0.4 | 0.4 | 0.4 | 0.4 | 0.4 | 0.4 | 0.4 | 0.4 |
| | General Security | 32,558.0 | 0.5 | 20.3 | 31.2 | 32.6 | 4.0 | 32.6 | 32.6 | 32.6 |
| Victorian Murray below Barmah Choke | High reliability water share | 78,721.9 | 7.1 | 78.7 | 78.7 | 78.7 | 22.8 | 78.7 | 78.7 | 78.7 |
| | Low reliability water share | 5,451.3 | 0.0 | 5.4 | 5.5 | 5.5 | 0.0 | 5.5 | 5.5 | 5.5 |
| Murrumbidgee* | General Security | 64,959.0 | 6.5 | 27.3 | 35.7 | 41.6 | 6.5 | 44.2 | 65.0 | 65.0 |
| | Supplementary | 20,820.0 | 0.0 | 0.0 | 0.0 | 20.8 | 0.0 | 0.0 | 0.0 | 20.8 |
| Goulburn | High reliability water share | 64,919.6 | 13.0 | 64.9 | 64.9 | 64.9 | 18.2 | 64.9 | 64.9 | 64.9 |
| | Low reliability water share | 10,480.0 | 0.0 | 0.4 | 5.7 | 10.0 | 0.0 | 1.8 | 8.2 | 10.5 |
| Broken* | High reliability water share | 20.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| | Low reliability water share | 4.2 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Campaspe | High reliability water share | 5,124.1 | 1.7 | 5.1 | 5.1 | 5.1 | 2.2 | 5.1 | 5.1 | 5.1 |
| | Low reliability water share | 395.4 | 0.0 | 0.4 | 0.4 | 0.4 | 0.0 | 0.4 | 0.4 | 0.4 |
| Loddon | High reliability water share | 1,179.0 | 0.0 | 1.2 | 1.2 | 1.2 | 0.0 | 1.2 | 1.2 | 1.2 |
| | Low reliability water share | 527.3 | 0.0 | 0.0 | 0.3 | 0.5 | 0.0 | 0.1 | 0.4 | 0.5 |
| South Australia | High reliability | 43,297.4 | 19.0 | 43.3 | 43.3 | 66.9 | 26.6 | 43.3 | 43.3 | 44.3 |
| **Total below Barmah Choke** | | | **48.1** | **247.4** | **272.3** | **328.6** | **80.8** | **278.1** | **305.6** | **329.9** |
| **Total** | | | **53.2** | **382.6** | **459.5** | **522.3** | **109.5** | **471.8** | **499.4** | **523.6** |

* Commonwealth holdings on the Ovens and Broken system and supplementary holdings on the Murrumbidgee system cannot be traded outside of the source trading zone. As such, holdings in these basins do not contribute to total water availability.

Whilst it is useful to consider water availability and potential allocations under different climatic conditions (extreme dry, dry, median, wet), it is important to recognise that conditions are not necessarily discrete or independent. It is recommended that watering options are reviewed on a seasonal basis, taking into account the outlook and developing conditions, recent water regimes and water quality conditions.

## 8.3 Water availability forecasts

A description of likely water availability for the Loddon, Goulburn and Campaspe systems is provided by G-MW when allocation announcements are made. Allocation announcements are generally made on the 15th of each month (or the next business day), however when allocations to high reliability water shares are less than 100 per cent allocation announcements are made on the 1st and 15th of each month (or the next business day).

The current allocation announcement and a description of likely future water availability for the remainder of the season can be sourced from: http://g-mwater.com.au/news/allocation-announcements/current.asp. Historical announcements and forecasts can be sourced from: http://g-mwater.com.au/news/allocation-announcements/archive.asp.

Additionally, G-MW publishes a seasonal allocation outlook prior to the start of each irrigation season, providing a forecast for October and February allocations for the following season. The seasonal allocation outlooks are published on G-MW's website (see Media Releases http://www.g-mwater.com.au/news/media-releases).

Note that in years with high water availability, only the seasonal allocation outlook can be prepared (i.e. water availability forecasts cannot be provided with allocation announcements).

# PART 3:
## Monitoring and Future Options

# 9. Monitoring, evaluation, and improvement

Assessing ecosystem response to specific environmental flow releases as a form of intervention analysis is a challenging exercise (Chee et al. 2006). Being able to apply traditional study designs (e.g. before-after-control-impact) is usually problematic, as control sites are usually lacking (i.e. there is not another Loddon River) and establishing 'before' conditions is difficult given the nature of river regulations and flows delivered from natural rainfall-runoff events. A number of monitoring and evaluation programs already exist that include the Loddon River. However, nearly all of these programs were established for purposes such as water quality and river condition reporting, rather than specifically for assessing ecosystem effects resulting from changes to the flow regime. The Victorian Environmental Flows Monitoring and Assessment Program (VEFMAP) was established specifically to assess ecosystem response to new environmental flow regimes. VEFMAP is currently being implemented across northern Victorian rivers, including the Goulburn, Campaspe and Loddon Rivers (Chee et al. 2006, SKM 2007).

The adoption of adaptive management could be useful for improving the outcomes of environmental water delivery. Adaptive management requires that the objectives, conceptual basis, implementation and evaluation of environmental releases are clearly articulated and analysed in order to learn from experience and inform future decisions. Evaluating the effectiveness of previously delivered flow events should also be the first action taken when planning for water management in subsequent years. While VEFMAP provides a useful conceptual basis and will provide long-term information on the effectiveness of environmental flow releases, it is based on longer-term objectives (e.g. five-year) across numerous rivers assuming 'typical' climatic and hydrological conditions (Chee et al. 2006). Evaluating the effectiveness of environmental water may also require dedicated short-term investigation on mechanistic responses and evaluation of water management within and among individual assets such as the Boort wetlands (i.e. smaller scale hypotheses than for VEFMAP) to provide information on which to base future decisions.

The following sections provide a guide to the parameters to be considered for future monitoring of environmental water releases. They do not provide guidance on aspects of study design, site selection and sampling frequency.

## 9.1 Existing monitoring programs and frameworks

SKM (2007) provided an overview of current monitoring programs that include the Loddon River. Existing information and monitoring includes:

- Cross-section surveys undertaken during environmental flow studies.
- Monthly water quality monitoring undertaken as part of the Victorian Water Quality Monitoring Network (VWQMN), as well as local monitoring of dissolved oxygen, temperature, turbidity, pH and electrical conductivity (NC CMA 2010).
- Fish surveys undertaken as part of the Murray-Darling Basin Sustainable Rivers Audit (SRA) and local investigations.
- Macroinvertebrate sampling undertaken by the Environment Protection Authority Victoria as part of its fixed sites network and as part of the SRA.

There are numerous long-term flow gauges along the Loddon River. Key streamflow gauges along the river are listed in Table 20. A full list of available streamflow gauges can be found on the Victorian Water Resources Data Warehouse (DSE 2010), which also includes monitoring sites on distributaries of the Loddon River. G-MW collects operational flow data along the Waranga Western Channel and storage volume data in the headworks storages, which can be requested directly from G-MW.

**Table 20:** Key flow monitoring gauges in the Loddon River catchment.

| Site number | Site name | Relevance |
|---|---|---|
| 407210 | Loddon River at Cairn Curran Reservoir | E-flow Reach 1 compliance point |
| 407248 | Tullaroop Creek at Tullaroop Reservoir | E-flow Reach 2 compliance point |
| 407229 | Loddon River at Serpentine Weir | E-flow Reach 3 compliance point |
| 407224 | Loddon River downstream of Loddon Weir | Flow to lower Loddon River |
| 407205 | Loddon River at Appin South | E-flow Reach 4 compliance point |
| 407202 | Loddon River at Kerang | E-flow Reach 5 compliance point |

## 9.2 Operational water delivery monitoring

Monitoring the delivery of environmental water along the Loddon River can be undertaken using the flow gauging sites previously listed. In addition, SEWPaC has a pro forma Operational Monitoring Report (Appendix 2) to capture information related to releases, such as event details, risk management, initial observations and other issues.

## 9.3 Key parameters for monitoring and evaluating ecosystem response

### 9.3.1 Loddon River

The proposed environmental watering objectives for the Loddon River (see section 2) relate to the delivery of flow components that support the following:

- Geomorphology:
  - Maintain channel form and processes along the main channel of the Loddon and its system of anastomosing distributaries, such as Twelve Mile Creek, Kinyapanial Creek, Bannagher Creek and Venables Creek.
- Vegetation:
  - Maintain/rehabilitate in-stream aquatic vegetation and ecological processes.
  - Control existing invasion of main channel with non-aquatic species.
  - Maintain/rehabilitate flood-dependent riparian and floodplain ecological vegetation classes (EVC).
  - Rehabilitate river-floodplain ecological interactions and ecological processes on floodplain.
- Water quality:
  - Reduce incidence and severity of blackwater events.
  - Limit impacts associated with acid sulfate soils.
- Fish:
  - Maintain pools or depressions in the bottom of the channel that fish may opportunistically use when wet.
- Macroinvertebrates:
  - Maintain habitat quality.

A detailed program to monitor and evaluate ecosystem responses to environmental flows along the Loddon River has been established as part of the VEFMAP (Chee et al. 2006) (Appendix 3). The monitoring and investigations established under VEFMAP provide a valuable starting point from which to assess ecosystem response to environmental flows, including those that may result from using environmental water.

If environmental water managers wish to evaluate specific releases of environmental water, they should liaise with VEFMAP stakeholders to establish appropriate 'before' conditions from which to assess ecosystem responses once environmental water is delivered. For details on the recommended measures and sampling regime see Chee et al. (2006). Additional monitoring could include the following (SKM 2007):

- Physical habitat surveys:
  - river cross sections
  - qualitative estimate of habitat area and velocity
  - visual estimate of substratum composition
  - woody debris load assessment.

- Water quality assessment:
  - monthly in-situ physico-chemical water quality monitoring (e.g. DO, pH, EC, temperature, suspended solids, nutrients)
  - continuous dissolved oxygen, temperature and electrical conductivity.
- Riparian and in-channel vegetation surveys.
- Adult fish surveys.

## 9.4 Potential monitoring gaps

VEFMAP was established to assess ecosystem responses to changes to watering regimes over time. It was not designed to assess ecosystem responses to individual or short-term flow events. The main issue for assessing the effectiveness of environmental water (in isolation) is to establish a study design that provides the best possible inference that ecosystem response is due to any particular environmental release(s). Particular attention will be required to establish the 'before' conditions to allow 'before-after' comparisons. Appropriate experimental designs are best considered once the environmental water manager determines the type for flow release(s) (e.g. baseflow, fresh, overbank flow). Monitoring considerations when planning to deliver environmental water are summarised in Table 21 (see also Appendix 3 for references to VEFMAP).

**Table 21:** Monitoring considerations for assessing the effectiveness of environmental water in Reach 4 of the Loddon River.

| Asset/ecosystem attribute | Objective | Hypotheses and indicators | Existing monitoring | Additional monitoring required | Comments |
|---|---|---|---|---|---|
| Geomorphology | • Maintain channel form and processes along the main channel of the Loddon and its system of anastomosing distributaries. | • VEFMAP hypotheses and indicators are mostly appropriate. | • Channel form is monitored at two sites every five years, or following large events.<br>• There is no monitoring of distributaries such as Kinyapanial Creek. | • Survey of distributaries. | • Environmental water managers may consider contributing to a channel survey to provide new baseline conditions if this has not been done since the 2010 floods. |
| Water quality | • Improve water quality.<br>• Reduce incidence and severity of blackwater events.<br>• Limit impacts associated with acid sulfate soils (ASS). | • VEFMAP does not include hypotheses related to water quality. | • Water quality is currently monitored at two sites for continuous DO, EC and temperature, as well as monthly physico-chemical parameters. | • Event-based monitoring. | • Water quality hypotheses require development to test response to the delivery of environmental water in isolation. |
| Riparian and in-channel vegetation | • Maintain/rehabilitate in-stream aquatic vegetation and ecological processes in main channel.<br>• Control existing invasion of main channel with non-aquatic species.<br>• Maintain/rehabilitate flood-dependent riparian and floodplain EVCs.<br>• Rehabilitate river-floodplain ecological interactions and ecological processes on floodplain. | • VEFMAP hypotheses and indicators are mostly appropriate. | • Vegetation is monitored at two sites every three to five years. | • Frequency and timing of monitoring (before-after) should coincide with individual watering events should the environmental water manager seek to measure the effect of environmental water in isolation from the wider water regime. | • VEFMAP can provide baseline information for assessing effects of environmental water on vegetation. However, additional or repeated measurements may be required to provide 'before' data in light of recent (2010) flood events. |
| Native fish | • Maintain pools or depressions in the bottom of the channel that fish may opportunistically use when wet. | • VEFMAP hypotheses and indicators are appropriate. | • Adult fish are monitored annually at four sites. | • As above. | • As above. |
| Macroinvertebrates | • Maintain habitat quality. | • Some but not all VEFMAP hypotheses are suitable (e.g. hypotheses related to AusRivas are not suitable). | • No macroinvertebrate monitoring is undertaken as part of VEFMAP. Habitat is monitored at two sites every five years or after events. | • As above. | • As above. |

### 9.4.1 Boort wetlands

Environmental watering of the Boort district wetlands seeks to meet the needs of wetland vegetation as well as provide habitat for waterbirds, fish and invertebrates (NC CMA 2010b, c, d). Recent monitoring by the North Central CMA has included a vegetation survey at many of the wetlands and establishment of photo-points to assess vegetation changes over time. The scale and frequency of monitoring at the wetlands is currently constrained by limited resources. Additional funding will be required if the full suite of activities described below is to be implemented.

#### *Vegetation*

Previous vegetation surveys and records are available for the wetlands that provide baseline data from which to evaluate any ecosystem response to environmental watering. It is recommended that this information be reviewed, and updated if necessary, prior to delivering environmental water. Monthly monitoring is recommended thereafter, to assess response over time. This could include (NCCMA 2010b, c, d):

- distribution mapping
- photo points
- species lists.

#### *Waterbirds*

Monthly monitoring as water levels fluctuate is recommended for measuring the response of bird communities captured (Baldwin et al. 2005, cited in NC CMA 2010b, c) including:

- area searches
- nest surveys.

Spring surveys are required to monitor breeding events and to inform the adaptive management of the water regime (i.e. providing top-ups to maintain water levels in order to complete breeding events). Numerous previous surveys and records are available to provide baseline data in order to evaluate the response of waterbirds to the provision of water. Databases have been compiled for each wetland and these should be updated regularly following monitoring.

#### *Fish, amphibians and macroinvertebrates*

Numerous surveys and records exist to provide baseline data from which to assess ecosystem response to watering (NC CMA 2010b, c, d). Monitoring could include (Baldwin et al. 2005, cited in NC CMA 2010b, c, d):

- Fish – electrofishing, bait trapping, seine and fyke netting.
- Amphibians – call playback, funnel trapping, drift fences and pit traps.
- Macroinvertebrates – sweep netting.

Databases have also been compiled for the wetlands (NC CMA 2010b, c) and should be updated regularly following monitoring. Monitoring results can also be used to assess the habitat availability for waterbirds, as fish, amphibians and macroinvertebrates are a significant food source for many waterbird species.

#### *Water Quality*

A monthly water quality monitoring program could include:

- electrical conductivity
- pH
- turbidity
- nutrients.

# 10. Opportunities

## 10.1 Irrigation system opportunities

Tandarra Pondage is a 2,800 ML balancing storage along the Waranga Western Channel approximately 44 kilometres upstream of Loddon Weir. This storage could potentially be used to assist in delivering water to the lower Loddon River from the Waranga Western Channel. Environmental water managers could explore options with G-MW to use water from the storage when there are channel capacity constraints upstream of the pondage. The pondage can potentially be used during the winter shutdown period. G-MW would need to program its maintenance to keep the section of channel from the pondage to Loddon Weir operational during times when environmental water deliveries are desired.

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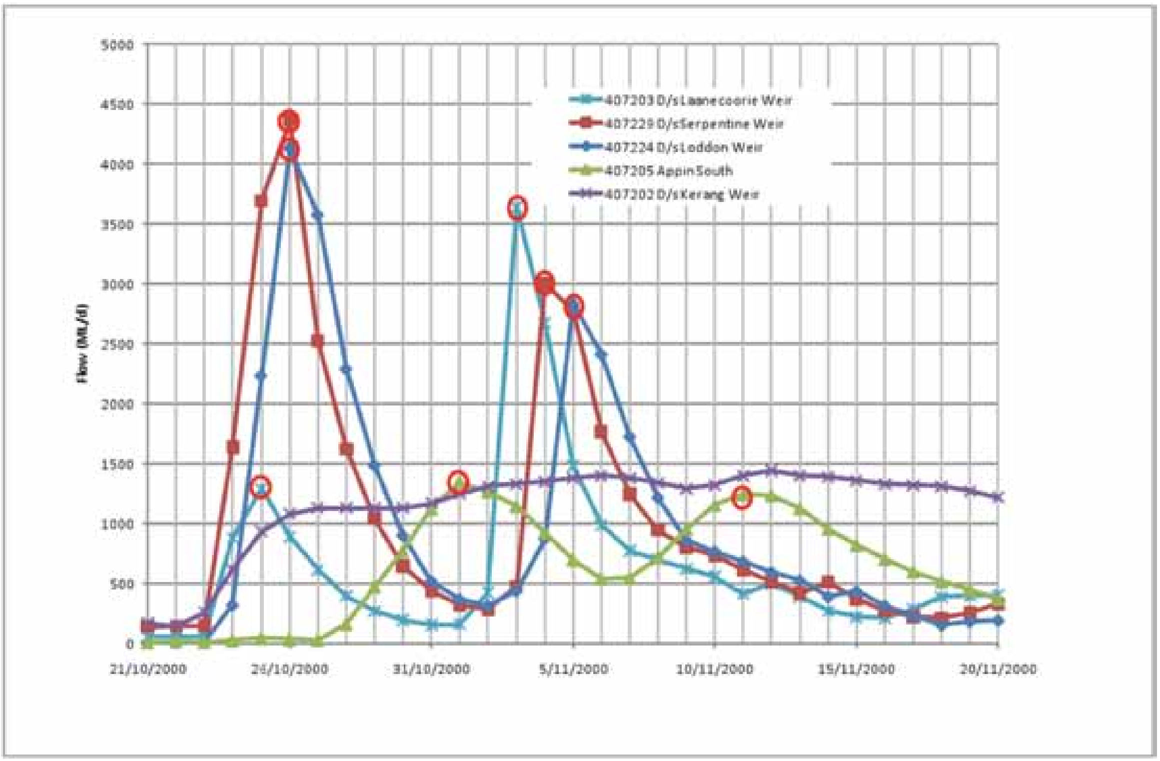
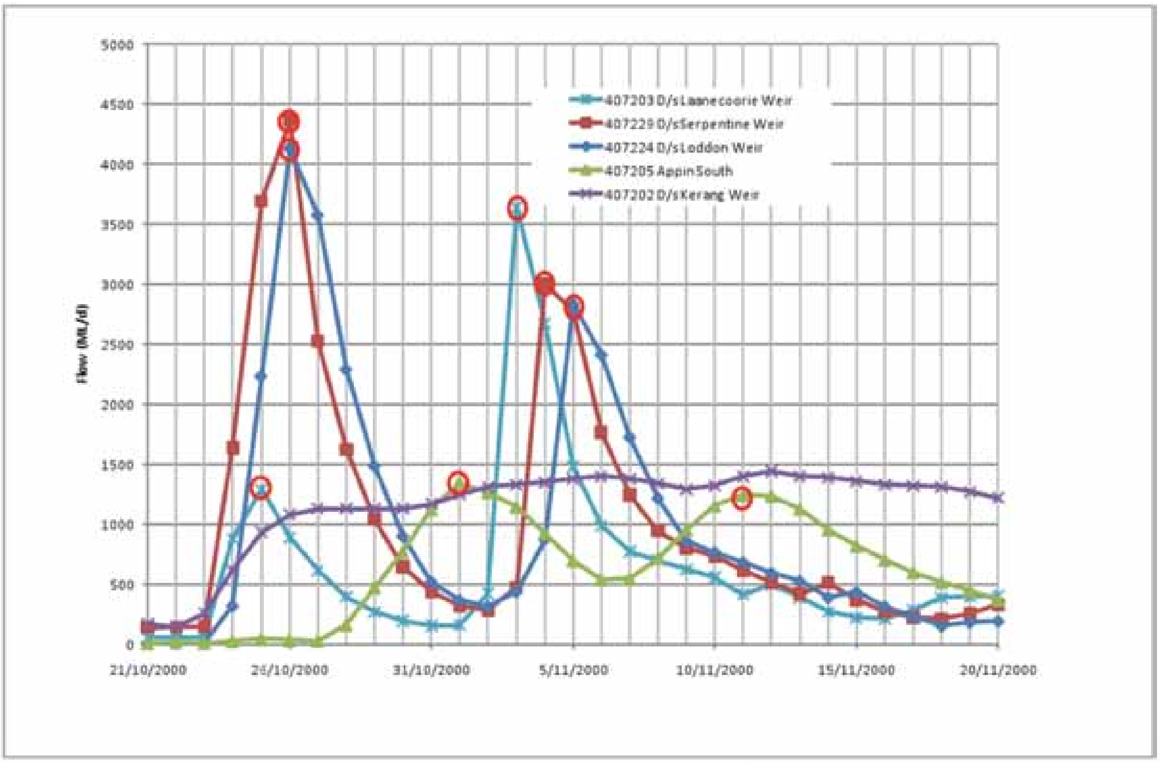
# Appendix 1: Loddon River travel time



# Appendix 2: Operational Monitoring Report

| | | |
|---|---|---|
| *Commonwealth Environmental Watering Program*<br><br>*Operational Monitoring Report*<br><br>*Please provide the completed form to <insert name and email address>, within two weeks of completion of water delivery or, if water delivery lasts longer than two months, also supply intermediate reports at monthly intervals.*<br><br>Final Operational Report Intermediate Operational Report Reporting Period: From To | | |
| **Site name** | | **Date** |
| Location | GPS Coordinates or Map Reference for site (if not previously provided) | |
| Contact Name | *Contact details for first point of contact for this watering event* | |
| Event details | *Watering Objective(s)* | |
| | *Total volume of water allocated for the watering event*<br><br>*Commonwealth Environmental Water:*<br><br>*Other (please specify) :* | |
| | *Total volume of water delivered in watering event*<br><br>*Commonwealth Environmental Water:*<br><br>*Other (please specify):* | *Delivery measurement*<br><br>*Delivery mechanism:*<br><br>*Method of measurement:*<br><br>*Measurement location:* |
| | *Delivery start date (and end date if final report) of watering event* | |
| | *Please provide details of any complementary works* | |
| | *If a deviation has occurred between agreed and actual delivery volumes or delivery arrangements, please provide detail* | |
| | *Maximum area inundated (ha) (if final report)* | |
| | *Estimated duration of inundation (if known)*[1] | |
| Risk management | *Please describe the measure(s) that were undertaken to mitigate identified risks for the watering event (eg. water quality, alien species); please attach any relevant monitoring data.*<br><br>*Have any risks eventuated? Did any risk issue(s) arise that had not been identified prior to delivery? Have any additional management steps been taken?* | |
| Other Issues | *Have any other significant issues been encountered during delivery?* | |
| Initial Observations | *Please describe and provide details of any species of conservation significance (state or Commonwealth listed threatened species, or listed migratory species) observed at the site during the watering event?* | |
| | *Please describe and provide details of any breeding of frogs, birds or other prominent species observed at the site during the watering event?* | |
| | *Please describe and provide details of any observable responses in vegetation, such as improved vigour or significant new growth, following the watering event?* | |
| | *Any other observations?* | |
| Photographs | *Please attach photographs of the site prior, during and after delivery*[2] | |

1 Please provide the actual duration (or a more accurate estimation) at a later date (e.g. when intervention monitoring reports are supplied).

2 For internal use. Permission will be sought before any public use.

# Appendix 3: Summary of VEFMAP monitoring

Summary of VEFMAP monitoring arrangements for environmental water use in Reach 4 of the Loddon River (from SKM 2007, Chee et al. 2006).

| Flow component | Hypotheses | Indicator(s) | Monitoring sites | Frequency | Considerations for this watering options project |
|---|---|---|---|---|---|
| **Geomorphology** | | | | | |
| Winter/spring freshes | Does increased frequency of winter-spring fresh events:<br><br>a) increase the frequency of geomorphologically significant events (e.g. redistribution of bed and bank sediments)?<br><br>b) increase channel complexity (e.g. areas of the stream bed which are flushed free of fine deposits, deeper pools and variability in bench elevations)?<br><br>c) increase channel width and depth?<br><br>d) increase rates of meander development (i.e. bank erosion on the outside bank, point bar development, increased sinuosity and eventually bend cut-off and billabong formation)? | Flow and physical habitat (channel dimensions) to assess:<br><br>• Frequency of channel disturbances<br>• Frequency of bed disturbances<br>• Rate of bench deposition<br>• Bed complexity<br>• Bench development and variability<br>• Mean channel top width, cross-section area and thalweg depth<br>• Bank erosion on outside of meander bends<br>• Point bar development. | Two | Every five years, event based. | VEFMAP provide baseline information for assessing effects of environmental water. May require repeat measurements to provide 'before' data if channel dimensions have not been surveyed after recent (2010) flood events. |
| Bankfull | As above | As above | As above | As above | As above |

| Flow component | Hypotheses | Indicator(s) | Monitoring sites | Frequency | Considerations for this watering options project |
|---|---|---|---|---|---|
| **Habitat & macroinvertebrates** | | | | | |
| Summer/autumn low flows and freshes | • Do implemented environmental flows maintain in-channel shallow and slow water areas?<br>• Do implemented environmental flows maintain adequate area and depth of at least 0.1 m in shallow, slow water and riffle/run habitats?<br>• Do implemented environmental flows maintain adequate volume and depth in permanent pools?<br>• Do implemented environmental flows maintain connectivity?<br>• Do implemented environmental flows maintain macroinvertebrate community structure?<br>• Do implemented environmental flows increase fish recruitment?<br>• Do implemented environmental flows maintain fish assemblages and/or population structure? | • Shallow and slow water area<br>• Riffle/run depth and area<br>• Permanent pool depth and volume<br>• Connectivity<br>• Number of invertebrate families index<br>• AUSRIVAS score<br>• SIGNAL biotic index<br>• EPT biotic index<br>• Presence/absence and number of 'flow-sensitive' taxa<br>• See conceptual model for fish spawning and recruitment<br>• Fish species composition<br>• Relative abundance of adult/sub-adult native and exotic fish species<br>• Population structure and size class distribution of native and exotic fish species. | Physical habitat at two sites.<br><br>***Macroinvertebrates in the Loddon are not monitored as part of VEFMAP.*** | Every five years, event based. | As above<br><br>VEFMAP sampling was not designed to assess short-term changes. Will require more frequent 'before' and 'after' sampling if the effects of specific watering actions are to be assessed in isolation. |

| Flow component | Hypotheses | Indicator(s) | Monitoring sites | Frequency | Considerations for this watering options project |
|---|---|---|---|---|---|
| Winter/spring baseflows | • Do implemented environmental flows increase in-channel shallow and slow water areas?<br>• Do implemented environmental flows increase area of riffle and/or run habitat?<br>• Do implemented environmental flows increase volume of permanent pool habitats?<br>• Do implemented environmental flows result in sustained inundation of in-channel macrophytes, channel edge macrophytes, tree roots, woody debris, branch piles, in-channel bars, overhanging or undercut banks?<br>• Do implemented environmental flows increase abundance of macrophytes?<br>• Do implemented environmental flows improve macroinvertebrate community structure?<br>• Do implemented environmental flows improve fish assemblages and/or population structure? | • Shallow and slow water area<br>• Riffle and/or run area<br>• Permanent pool depth and volume<br>• Inundation of representative physical habitat features<br>• See conceptual model for aquatic and riparian vegetation<br>• Cover of submerged and amphibious species<br>• Cover of submerged and amphibious species<br>• Number of invertebrate families index<br>• AUSRIVAS score<br>• SIGNAL biotic index<br>• EPT biotic index<br>• Presence/absence and number of 'flow-sensitive' taxa<br>• Fish species composition<br>• Relative abundance of adult/sub-adult native and exotic fish species<br>• Population structure and size class distribution of native and exotic fish species. | As above | As above | As above<br><br>VEFMAP sampling was not designed to assess short-term changes. Will require more frequent 'before' and 'after' sampling if the effects of specific watering actions are to be assessed in isolation. |

| Flow component | Hypotheses | Indicator(s) | Monitoring sites | Frequency | Considerations for this watering options project |
|---|---|---|---|---|---|
| Winter/spring freshes | • Do implemented environmental flows increase area of riffle and/or run habitat?<br>• Do implemented environmental flows increase volume of pool habitats?<br>• Do implemented environmental flows result in temporary inundation of higher-level channel edge macrophytes, tree roots, woody debris, bars, benches, overhanging/undercut banks?<br>• Do implemented environmental flows improve macro invertebrate community structure?<br>• Do implemented environmental flows improve fish assemblages and/or population structure? | • Riffle and/or run area<br>• Permanent pool depth and volume<br>• Inundation of higher elevation representative physical habitat features<br>• Number of invertebrate families index<br>• AUSRIVAS score<br>• SIGNAL biotic index<br>• EPT biotic index<br>• Presence/absence and number of 'flow-sensitive' taxa<br>• Fish species composition<br>• Relative abundance of adult/sub-adult native and exotic fish species<br>• Population structure and size class distribution of native and exotic fish species. | As above | As above | As above |

| Flow component | Hypotheses | Indicator(s) | Monitoring sites | Frequency | Considerations for this watering options project |
|---|---|---|---|---|---|
| **Aquatic & riparian vegetation** | | | | | |
| Spring baseflow | • Do implemented environmental flows increase in-channel shallow and slow water area?<br>• Do implemented environmental flows increase run areas?<br>• Do implemented environmental flows result in sustained inundation of channel bed, channel edges, in-channel bars, low-lying benches, runners and anabranches in Zone A*?<br>• Do implemented environmental flows<br>a) increase germination and seasonal growth of submerged and amphibious fluctuation-responder species in Zone A*?<br>b) reduce species richness of terrestrial 'dry' species in Zone A*? | • Shallow and slow water areas<br>• Run depth and area<br>• Inundation of geomorphic features in Zone A*<br>• Cover of submerged and amphibious species in Zone A*<br>• Species composition, number of submerged, amphibious and terrestrial species in Zone A*<br>• Proportion of exotic plant species. | Two sites | Every three to five years, late spring | As above |
| | • What is the pattern of inundation and drying in Zones A* & B* imposed by the implemented environmental flows?<br>• What is the composition of the resultant plant community? | • Cover of amphibious and terrestrial species in Zones A* & B*<br>• Species composition, number of amphibious and terrestrial species in Zones A* & B*<br>• Proportion of exotic plant species | As above | As above | As above |

| Flow component | Hypotheses | Indicator(s) | Monitoring sites | Frequency | Considerations for this watering options project |
|---|---|---|---|---|---|
| Spring freshes & bankfull flows | • Do implemented environmental flows wet high-level benches, upper banks, runners and anabranches in Zones B* & C*?<br>• Do implemented environmental flows increase germination and establishment of terrestrial 'damp', terrestrial 'dry' and amphibious fluctuation-tolerator species?<br>• Do implemented environmental flows improve canopy condition of in situ riparian trees and shrubs? | • Wetting of geomorphic features in Zones B* & C*<br>• Species composition, number of amphibious and terrestrial species in Zones B* & C*<br>• Proportion of exotic plant species<br>• Germination of seedlings of overstorey and mid-storey species<br>• Canopy condition. | As above | As above | As above |
| Summer baseflow | • Do implemented environmental flows maintain area of in-channel shallow and slow water and run habitats?<br>• Do implemented environmental flows wet in-channel bars, low-lying benches, channel edges, runners and anabranches in Zone A*?<br>• Do implemented environmental flows improve canopy condition of adjacent riparian trees and shrubs? | • See conceptual model for habitat processes<br>• Shallow and slow water area<br>• Run depth and area.<br>• Wetting of geomorphic features in Zone A*<br>• Canopy condition. | - | - | As above |
| **Native fish** | | | | | |
| Autumn-early winter freshes/ bankfull flows | • Do implemented environmental flows trigger spawning of diadromous fish? (Only relevant in river reaches inhabited by diadromous fish species such as galaxiids, eels and Australian grayling) | • Presence/absence of diadromous fish larvae. | - | - | VEFMAP may be appropriate for considering effects of environmental water, but it may also be difficult to separate from other influences, including recent flow history (i.e. antecedent conditions). |

| Flow component | Hypotheses | Indicator(s) | Monitoring sites | Frequency | Considerations for this watering options project |
|---|---|---|---|---|---|
| Winter-spring baseflows and winter-spring freshes | • Do implemented environmental flows increase overall quantity and diversity of in-stream habitat? | • See conceptual model for habitat processes<br>  • Shallow and slow water area<br>  • Run area<br>  • Permanent pool depth and volume<br>  • Inundation of physical habitat features<br>  • Inundation of higher elevation physical habitat features<br>  • In-channel and littoral cover of macrophytes. | Four sites | Annually, November–April | As above |
| Spring-early summer bankfull flows | • Do implemented environmental flows inundate low-lying runners and anabranches to create increased slackwater habitat?<br>• Do implemented environmental flows increase the number of fish completing larval stages? | • Area of slackwater habitat in runners and anabranches<br>• Density of post-larval fish. | Four sites | Annually, November–April | As above |
| Spring-early summer base flows | • Do implemented environmental flows provide appropriate conditions for spawning and larval production of 'low flow specialist' and generalist fish species?<br>• Do implemented environmental flows maintain adequate in stream habitat for adult and larval fish?<br>• Do implemented environmental flows increase the number of fish completing larval stages? | • Presence/absence of 'low flow specialist' and generalist fish larvae<br>• See conceptual model for Habitat Processes<br>  • Shallow and slow water area<br>  • Run area<br>  • Permanent pool depth and volume<br>  • Connectivity<br>• Density of post-larval fish. | Four sites | Annually, November–April | As above |

| Flow component | Hypotheses | Indicator(s) | Monitoring sites | Frequency | Considerations for this watering options project |
|---|---|---|---|---|---|
| Spring-early summer overbank flows | • Do implemented environmental flows inundate low-lying runners and anabranches to create increased slackwater habitat?<br>• Do implemented environmental flows inundate floodplain areas to create increased slackwater habitat?<br>• Do implemented environmental flows provide appropriate conditions for spawning and larval production of 'flood specialist' non-diadromous fish species?<br>• Do implemented environmental flows increase the number of fish completing larval stages? | • Area of slackwater habitat in runners and anabranches<br>• Area of slackwater habitat in floodplain<br>• Presence/absence of 'flood specialist' non-diadromous fish larvae<br>• Density of post-larval fish. | Four sites | Annually, November–April | As above |
| Summer-autumn low flows | • Do implemented environmental flows maintain adequate in-stream habitat for adult and larval fish?<br>• Do implemented environmental flows increase the number of fish completing larval stages? | • See conceptual model for habitat processes<br>  • Shallow and slow water area<br>  • Run area<br>  • Permanent pool depth and volume<br>  • Connectivity<br>• Density of post-larval fish. | Four sites | Annually, November–April | As above |

| Flow component | Hypotheses | Indicator(s) | Monitoring sites | Frequency | Considerations for this watering options project |
|---|---|---|---|---|---|
| **Water Quality** | | | | | |
| All components (year-round) | • No specific hypotheses | Colour, dissolved organic carbon, dissolved reactive phosphorus, electrical conductivity, total Kjeldahl nitrogen, oxidised nitrogen, pH, total phosphorus and turbidity. | Two sites | Continuous DO, EC and temperature.<br><br>Monthly physico-chemical measurements. | Dedicated monitoring program may be required, depending on the water quality variable to be tested. |

*Zone A: From mid-channel to stream margin (or the area covered by water during times of baseflow).

Zone B: From stream margin to a point mid-way up the flank of the bank (or the point that is infrequently inundated).

Zone C: From mid-way up the flank of the bank to just beyond the top of the bank.

# Appendix 4: Recommended Objectives and Hydrological regime for Lake Yando (NC CMA 2010b)

| Ecological Objective | Justification | Hydrological Requirement |
|---|---|---|
| **1. Habitiat Objectives** | | |
| 1.1 Maintain the health and restore the distribution of river red gum (EVC 292)<br>• Maintain health of existing trees<br>• Provide opportunities for recruitment in the western half of the wetland | River red gum trees provide hollows, fallen branches and shading for habitat, and provide a source of seed for recruitment. | Inundate to FSL (87.59m AHD[10]) one in three years and allow natural draw-down over approximately five months. |
| 1.2 Maintain open water and associated mudflat habitat in sections of the wetland | Provides habitat for waterbirds e.g. Australiasian Shoveler, Intermediate Egret, Eatern Great Egret, Hardhead, Musk Duck, Little Egret, Glossy Ibis. | Inundate to a minimum depth 50cm one in three years. |
| 1.3 Maintain the health and restore the distribution of the fringing Riverine Chenopd Woodland (EVC 103)<br>• Maintain health of existing trees<br>• Provide opportunities for recruitment | Black Box trees provide hollows, fallen branches and shading for habitat (e.g. White-bellied Sea-Eagle and Grey-crowned Babbler), and provide a source of seed for recruitment. | Inundate to 87.8m AHD one in six years for two to three months |
| 1.4 Maintain health and restore the distribution of Tangled Lignum vegetation across a greater range of elevations at Lake Yando | Tangled Lignum provides habitat for waterbirds e.g. Whiskered Tern, Freckled Duck | Inundate to 87.8m AHD one in six years for two to three months. |
| 1.5 Restore diverse aquatic and amphibious plant species communities in the Galgai microtopography. | Provide a range of micro-habitats to support a diverse array of plants, birds, frogs and invertebrates. | Inundate one in three years. |
| **2. Species/Community Objectives** | | |
| 2.1 Restore habitat for the rare Winged Water-starwort | Provide the habitat to support and expand the population of this rare plant species. | Little appears to be known about water requirements. |
| 2.2 Restore feeding and breeding opportunities for waterbirds, frogs and invertebrates | Linked to habitat objectives. Providing a variety of habitat types and high productivity of micro and macro-invertebrates and plant species through a wetting and drying cycle should enable breeding opportunities. | Fill to FSL (87.59m AHD) in spring and inundate for seven to ten months. |
| 2.3 Ensure a viable seed and egg bank is maintained | Seed and egg banks provide a source of survival for invertebrates and macrophytes in temporary wetlands during dry periods. These habitat and food sources in turn support higher order consumers such as waterbirds, frogs and fish. | Duration variable and seasonally dependant but maintain inundation for a minimum of three months one in three years. |

## *Desired water regime*

A desired water regime has been defined for Lake Yando and is presented on the previous page.

The proposed regime aims to reinstate an intermittent water regime at a wetland that has largely been dry since 1997 except for the 2010–11 flooding events.

**Timing:** Winter/spring

**Frequency of wetting:**

Minimum: one in five years.
Optimum: one in three years.
Maximum: one in two years.

**Duration:** Variable (habitat dependent). Approximately five months in Red Gum Swamp (EVC 292) vegetation allowing for natural draw-down, two to three months in areas of black box and tangled lignum vegetation (EVC 103: Riverine Chenopod Woodland). Top-ups may be required to maintain duration depending on the waterbird breeding response.

**Extent and depth:** Dependent on objective targeted.

- Inundate the base of wetland to a minimum depth of 50 centimetres for longer than three months, for river red gums and establishment of aquatic/amphibious plant species.
- Inundate entire wetland into black box and tangled lignum areas for two to three months. Depth not important.
- Allow draw-down via evaporation (duration of approximately five months unless top-ups are required in response to waterbird breeding) facilitating the exposure of mudflat habitat with receding water levels.

**Variability:** High (target levels and corresponding duration).

# Appendix 5: Important species recorded in the Loddon river and Boort wetlands

## *Loddon River*

Lower Loddon River (Laanecoorie Reservoir to the Murray River) threatened species list

| Species name | Common name | EPBC status | Migratory species | Presence* | FFG listing ** |
|---|---|---|---|---|---|
| **Flora** | | | | | |
| *Amphibromus fluitans* | River swamp wallaby-grass | V | | May | - |
| *Austrostipa metatoris* | | V | | Likely | - |
| *Austrostipa wakoolica* | | E | | Likely | - |
| *Cullen parvum* | Small scurf-pea | - | | Known | L |
| *Cullen tenax* | Tough scurf-pea | - | | Known | L |
| *Lepidium monoplocoides* | Winged pepper-cress | E | | Likely | L |
| *Maireana cheelii* | Chariot wheels | V | | Likely | - |
| *Pimelea spinescens subsp. spinescens* | Plains rice-flower | CE | | May | L |
| *Swainsona murrayana* | Slender darling-pea | V | | Likely | L |
| *Swainsona plagiotropis* | Red darling-pea, red Swainson-pea | V | | Known | L |
| **Invertebrates** | | | | | |
| *Synemon plana* | Golden sun moth | CE | | Known | L |
| **Fish** | | | | | |
| *Bidyanus bidyanus* | Silver perch | | | Known | L |
| *Craterocephalus fluviatilis* | Murray hardyhead | V | | May | L |
| *Maccullochella peelii peelii* | Murray cod | V | | Known | L |
| *Macquaria australasica* | Macquarie Perch | E | | Known | L |
| *Melanotaenia fluviatilis* | Crimson-spotted rainbowfish | - | | Known | L |
| **Amphibians** | | | | | |
| *Litoria raniformis* | Growling Grass Frog, Southern | V | | Known | L |
| **Reptiles** | | | | | |
| *Aprasia parapulchella* | Pink-tailed worm-lizard | V | | Likely | L |
| *Delma impar* | Striped legless lizard | V | | Likely | L |

| Species name | Common name | EPBC status | Migratory species | Presence* | FFG listing ** |
|---|---|---|---|---|---|
| **Birds** | | | | | |
| *Anseranas semipalmata* | Magpie goose | - | | Known | L |
| *Apus pacificus* | Fork-tailed swift | - | Marine | May | - |
| *Ardea alba* | Great egret, white egret | - | Marine / wetland | May | - |
| *Ardea ibis* | Cattle egret | - | Marine / wetland / terrestrial | May | - |
| *Gallinago hardwickii* | Latham's snipe, Japanese snipe | - | Wetland | May | - |
| *Grus rubicunda* | Brolga | - | | Known | L |
| *Haliaeetus leucogaster* | White-bellied sea-eagle | - | Terrestrial | Likely | L |
| *Hirundapus caudacutus* | White-throated needletail | - | Terrestrial | May | - |
| *Lathamus discolor* | Swift Parrot | E | | Likely | L |
| *Leipoa ocellata* | Malleefowl | V | - | Likely | L |
| *Merops ornatus* | Rainbow bee-eater | - | Terrestrial | May | - |
| *Pedionomus torquatus* | Plains-wanderer | V | - | Likely | L |
| *Polytelis swainsonii* | Superb parrot | V | | May | L |
| *Pomatostomus temporalis temporalis* | Grey-crowned babbler | - | | Known | L |
| *Rostratula australis* | Australian painted snipe | V | | May | L |
| *Rostratula benghalensis s. lat.* | Painted snipe | - | Wetland | May | - |
| *Stictonetta naevosa* | Freckled duck | - | | Known | L |
| *Xanthomyza phrygia* | Regent honeyeater | E | Terrestrial | May | L |
| **Mammals** | | | | | |
| *Nyctophilus timoriensis (South-eastern form)* | Greater long-eared bat | V | | May | L |

*E* Endangered
*CE* Critically endangered
*L* Listed (threatened)
*V* Vulnerable
* The presence of species has been ascertained through:
EPBC Act, Protected Matters Search Tool website
Department of Sustainability and Environment, **Biodiversity Interactive Map** website
Victorian Department of Sustainability and Environment (2007) Advisory List of Threatened Vertebrate Fauna in Victoria – 2007. Department of Sustainability and Environment, East Melbourne, Victoria.
** Department of Sustainability and Environment (2005) Advisory List of Rare or Threatened Plants in Victoria – 2005. Victorian Department of Sustainability and Environment, East Melbourne, Victoria.
Victorian Department of Sustainability and Environment (2009) Advisory List of Threatened Invertebrate Fauna in Victoria – 2009. Department of Sustainability and Environment, East Melbourne, Victoria.

## *Boort wetlands*

Lake Boort threatened species list

| Species | Common name | EPBC status | Migratory (EPBC) | Presence | FFG listing* | Source** |
|---|---|---|---|---|---|---|
| **Fish** | | | | | | |
| *Maccullochella peelii peelii* | Murray cod | V | | May | ✓ | EPBC |
| *Macquaria australasica* | Macquarie Perch | E | | May | ✓ | EPBC |
| **Amphibian** | | | | | | |
| *Litoria raniformis* | Growling Grass Frog, Southern | V | | Known | ✓ | NCCMA EPBC DSE |
| **Reptile** | | | | | | |
| *Delma impar* | Striped legless lizard | V | | Known | ✓ | EPBC |
| *Ramphotyphlops proximus* | Woodland blind snake | V | | Known | | NCCMA DSE |
| **Birds** | | | | | | |
| *Apus pacificus* | Fork-tailed swift | | ✓ | May | | EPBC |
| *Ardea alba* | Great egret, white egret | | ✓ | Known | | NCCMA EPBC |
| *Ardea ibis* | Cattle egret | | ✓ | May | | EPBC |
| *Ardea modesta* | Eastern great egret | | ✓ | Known | | DSE |
| *Gallinago hardwickii* | Latham's snipe, Japanese snipe | | ✓ | Known | | NCCMA EPBC DSE |
| *Haliaeetus leucogaster* | White-bellied sea-eagle | | ✓ | Likely | ✓ | EPBC DSE |
| *Hirundapus caudacutus* | White-throated needletail | | ✓ | May | | EPBC |
| *Lathamus discolor* | Swift Parrot | E | | Known | ✓ | NCCMA EPBC DSE |
| *Leipoa ocellata* | Malleefowl | V | | Likely | ✓ | EPBC |
| *Merops ornatus* | Rainbow bee-eater | | ✓ | May | | EPBC |
| *Oxyura australis* | Blue-billed duck | | | Known | ✓ | NCCMA DSE |
| *Pedionomus torquatus* | Plains-wanderer | V | | Likely | ✓ | EPBC |
| *Pimelea spinescens subsp. spinescens* | Plains rice-flower | CE | | May | ✓ | EPBC |
| *Polytelis swainsonii* | Superb parrot | V | | May | ✓ | EPBC |
| *Pomatostomus temporalis temporalis* | Grey-crowned babbler | | | Known | ✓ | NCCMA DSE |

| Species | Common name | EPBC status | Migratory (EPBC) | Presence | FFG listing* | Source** |
|---|---|---|---|---|---|---|
| *Porzana pusilla palustris* | Baillon's crake | | | Known | ✓ | NCCMA DSE |
| *Rostratula australis* | Australian painted snipe | V | | May | ✓ | EPBC |
| *Rostratula benghalensis s. lat.* | Painted snipe | | ✓ | May | | EPBC |
| *Sterna caspia* | Caspian tern | | ✓ | Known | ✓ | NCCMA DSE |
| *Stictonetta naevosa* | Freckled duck | | | Known | ✓ | NCCMA DSE |
| *Xanthomyza phrygia* | Regent honeyeater | E | ✓ | May | ✓ | EPBC |
| **Mammal** | | | | | | |
| *Nyctophilus timoriensis (South-eastern form)* | Greater long-eared bat | V | | May | ✓ | EPBC |

V Vulnerable
E Endangered
CE Critically endangered
* FFG Listing under the provisions of Part 3 of the *Flora and Fauna Guarantee Act 1988*
** Source EPBC: EPBC Act, Protected Matters Search Tool website (accessed 18 July 2011)
DSE: Department of Sustainability and Environment, Biodiversity Interactive Map website (accessed 18 July 2011).
NCCMA: NCCMA (2010). Lake Boort Environmental Watering Plan. Prepared for the Northern Victoria Irrigation Renewal Project, North Central Catchment Management Authority, Huntly, Victoria.

## *Lake Leaghur*

### Lake Leaghur threatened species list

| Species | Common name | EPBC status | Migratory (EPBC) | Presence | FFG listing* | Source** |
|---|---|---|---|---|---|---|
| **Flora** | | | | | | |
| *Amphibromus fluitans* | River swamp wallaby-grass | V | | May | | EPBC |
| *Lepidium monoplocoides* | Winged pepper-cress | E | | Likely | ✓ | EPBC |
| *Maireana cheelii* | Chariot wheels | V | | Likely | | EPBC |
| *Swainsona murrayana* | Slender darling-pea | V | | Likely | ✓ | EPBC |
| **Fish** | | | | | | |
| *Craterocephalus fluviatilis* | Murray hardyhead | V | | May | ✓ | EPBC |
| *Maccullochella peelii peelii* | Murray cod | V | | May | ✓ | EPBC |
| *Macquaria australasica* | Macquarie Perch | E | | May | ✓ | EPBC |
| *Tandandus tandanus* | Freshwater catfish | | | Known | ✓ | NCCMA |
| **Amphibians** | | | | | | |

| Species | Common name | EPBC status | Migratory (EPBC) | Presence | FFG listing* | Source** |
|---|---|---|---|---|---|---|
| *Litoria raniformis* | Growling Grass Frog, Southern | V | | Likely | ✓ | EPBC |
| **Reptile** | | | | | | |
| *Delma impar* | Striped legless lizard | V | | Known | ✓ | NCCMA EPBC |
| **Birds** | | | | | | |
| *Ardea ibis* | Cattle egret | | ✓ | May | | EPBC |
| *Gallinago hardwickii* | Latham's snipe, Japanese snipe | | ✓ | May | | EPBC |
| *Hirundapus caudacutus* | White-throated needletail | | ✓ | May | | EPBC |
| *Pedionomus torquatus* | Plains-wanderer | V | | Likely | ✓ | EPBC |
| *Polytelis swainsonii* | Superb parrot | V | | May | ✓ | EPBC |
| *Rostratula australis* | Australian painted snipe | V | | May | ✓ | EPBC |
| *Rostratula benghalensis s. lat.* | Painted snipe | | ✓ | May | | EPBC |
| *Apus pacificus* | Fork-tailed swift | | ✓ | May | | EPBC |
| *Ardea alba* | Great egret, white egret | | ✓ | Known | | EPBC |
| *Xanthomyza phrygia* | Regent honeyeater | E | ✓ | May | ✓ | EPBC |
| *Acrocephalus stentoreus* | Clamorous reed warbler | | ✓ | Known | | NCCMA |
| *Ardea intermedia* | Intermediate egret | | ✓ | Known | ✓ | NCCMA |
| *Chthonicola sagittata* | Speckled warbler | | | Known | ✓ | NCCMA |
| *Egretta garzetta* | Little egret | | | Known | ✓ | NCCMA |
| *Melanodryas cucullata cucullata* | Hooded robin | | | Known | ✓ | NCCMA |
| *Oreoica gutturalis* | Crested bellbird | | | Known | ✓ | NCCMA |
| *Plegadis falcinellus* | Glossy ibis | | ✓ | Known | | NCCMA |
| *Pomatostomus temporalis temporalis* | Grey-crowned babbler | | | Known | ✓ | NCCMA |
| *Stagonopleura guttata* | Diamond firetail | | | Known | ✓ | NCCMA |
| *Tringa nebularia* | Common greenshank | | ✓ | Known | | NCCMA |
| *Ardea modesta* | Eastern great egret | | ✓ | Known | | NCCMA DSE |
| *Oxyura australis* | Blue-billed duck | | | Known | ✓ | NCCMA DSE |

| Species | Common name | EPBC status | Migratory (EPBC) | Presence | FFG listing* | Source** |
|---|---|---|---|---|---|---|
| *Stictonetta naevosa* | Freckled duck | | | Known | ✓ | NCCMA DSE |
| *Haliaeetus leucogaster* | White-bellied sea-eagle | | ✓ | Known | ✓ | NCCMA DSE EPBC |
| *Lathamus discolor* | Swift Parrot | E | | Known | ✓ | NCCMA EPBC |
| *Merops ornatus* | Rainbow bee-eater | | ✓ | Known | | NCCMA EPBC |
| **Mammal** | | | | | | |
| *Nyctophilus timoriensis (South-eastern form)* | Greater long-eared bat | V | | May | ✓ | EPBC |

V Vulnerable

E Endangered

CE Critically endangered

* FFG Listing under the provisions of Part 3 of the *Flora and Fauna Guarantee Act 1988*

** Source EPBC: EPBC Act, Protected Matters Search Tool website (accessed 18 July 2011)

DSE: Department of Sustainability and Environment, Biodiversity Interactive Map website (accessed 18 July 2011).

NCCMA: NCCMA (2010). Lake Leaghur Environmental Watering Plan. Prepared for the Northern Victoria Irrigation Renewal Project, North Central Catchment Management Authority, Huntly, Victoria.

## *Lake Meran*

### Lake Meran threatened species list

| Species | Common name | EPBC status | Migratory (EPBC) | Presence | FFG listing* | Source ** |
|---|---|---|---|---|---|---|
| **Flora** | | | | | | |
| *Lepidium monoplocoides* | Winged pepper-cress | E | | Likely | ✓ | EPBC |
| *Maireana cheelii* | Chariot wheels | V | | Likely | | EPBC |
| *Swainsona murrayana* | Slender darling-pea | V | | Likely | ✓ | EPBC |
| *Swainsona swainsonioides* | Downy swainson-pea | | | Known | ✓ | NCCMA |
| **Fish** | | | | | | |
| *Bidyanus bidyanus* | Silver perch | | | Known | ✓ | NCCMA, DSE |
| *Craterocephalus fluviatilis* | Murray hardyhead | V | | May | ✓ | EPBC |
| *Maccullochella peelii peelii* | Murray cod | V | | May | ✓ | NCCMA, EPBC, DSE |
| *Macquaria australasica* | Macquarie Perch | E | | May | ✓ | EPBC |
| **Amphibians** | | | | | | |
| *Litoria raniformis* | Growling Grass Frog, Southern | V | | Likely | ✓ | EPBC |

| Species | Common name | EPBC status | Migratory (EPBC) | Presence | FFG listing* | Source ** |
|---|---|---|---|---|---|---|
| **Reptile** | | | | | | |
| *Delma impar* | Striped legless lizard | V | | May | ✓ | EPBC |
| **Birds** | | | | | | |
| *Acrocephalus stentoreus* | Clamorous reed warbler | | ✓ | Known | | NCCMA |
| *Apus pacificus* | Fork-tailed swift | | ✓ | May | | EPBC |
| *Ardea alba* | Great egret, white egret | | ✓ | May | | EPBC |
| *Ardea ibis* | Cattle egret | | ✓ | May | | EPBC |
| *Ardea modesta* | Eastern great egret | | ✓ | Known | | NCCMA, DSE |
| *Gallinago hardwickii* | Latham's snipe, Japanese snipe | | ✓ | Known | | EPBC |
| *Haliaeetus leucogaster* | White-bellied sea-eagle | | ✓ | Likely | ✓ | EPBC |
| *Hirundapus caudacutus* | White-throated needletail | | ✓ | May | | EPBC |
| *Lathamus discolor* | Swift Parrot | E | | Known | ✓ | EPBC |
| *Merops ornatus* | Rainbow bee-eater | | ✓ | Known | | NCCMA, EPBC |
| *Pedionomus torquatus* | Plains-wanderer | V | | Likely | ✓ | EPBC |
| *Pomatostomus temporalis temporalis* | Grey-crowned babbler | | | Known | ✓ | NCCMA |
| *Rostratula australis* | Australian painted snipe | V | | May | ✓ | NCCMA |
| *Rostratula benghalensis s. lat.* | Painted snipe | | ✓ | May | | EPBC |
| *Stagonopleura guttata* | Diamond firetail | | | Known | ✓ | NCCMA, DSE |
| *Sterna caspia* | Caspian tern | | ✓ | Known | ✓ | NCCMA, DSE |
| *Xanthomyza phrygia* | Regent honeyeater | E | ✓ | May | ✓ | EPBC |
| **Mammals** | | | | | | |
| *Nyctophilus timoriensis (South-eastern form)* | Greater long-eared bat | V | | May | ✓ | EPBC |

V Vulnerable
E Endangered
CE Critically endangered
* FFG Listing under the provisions of Part 3 of the *Flora and Fauna Guarantee Act 1988*
** Source EPBC: EPBC Act, Protected Matters Search Tool website (accessed 18 July 2011)
DSE: Department of Sustainability and Environment, Biodiversity Interactive Map website (accessed 18 July 2011)
NCCMA: NCCMA (2010). Lake Meran Environmental Watering Plan. Prepared for the Northern Victoria Irrigation Renewal Project, North Central Catchment Management Authority, Huntly, Victoria.

## *Lake Yando*

Lake Yando threatened species list

| Species name | Common name | EPBC status | Migratory (EPBC) | Presence | FFG listing* | Source** |
|---|---|---|---|---|---|---|
| **Flora** | | | | | | |
| *Amphibromus fluitans* | River swamp wallaby-grass | V | | May | | EPBC |
| *Lepidium monoplocoides* | Winged pepper-cress | E | | Likely | ✓ | EPBC |
| *Maireana cheelii* | Chariot wheels | V | | Likely | | EPBC |
| *Pimelea spinescens subsp. spinescens* | Plains rice-flower | CE | | May | ✓ | EPBC |
| *Swainsona murrayana* | Slender darling-pea | V | | Likely | ✓ | EPBC |
| **Fish** | | | | | | |
| *Craterocephalus fluviatilis* | Murray hardyhead | V | | may | ✓ | NCCMA DSE EPBC |
| *Maccullochella peelii peelii* | Murray cod | V | | May | ✓ | EPBC |
| *Macquaria australasica* | Macquarie Perch | E | | May | ✓ | EPBC |
| *Tandandus tandanus* | Freshwater catfish | | | Known | ✓ | NCCMA |
| **Amphibians** | | | | | | |
| *Litoria raniformis* | Growling Grass Frog, Southern | V | | Likely | ✓ | EPBC |
| **Reptiles** | | | | | | |
| *Delma impar* | Striped legless lizard | V | | May | ✓ | NCCMA epbc |
| **Birds** | | | | | | |
| *Apus pacificus* | Fork-tailed swift | | P | May | | EPBC |
| *Ardea alba* | Great egret, white egret | | P | May | | EPBC |
| *Ardea ibis* | Cattle egret | | P | May | | EPBC |
| *Ardea modesta* | Eastern great egret | | P | Known | | DSE |
| *Egretta garzetta* | Little egret | | | Known | ✓ | NCCMA |
| *Gallinago hardwickii* | Latham's snipe, Japanese snipe | | P | Known | | EPBC |
| *Haliaeetus leucogaster* | White-bellied sea-eagle | | P | Likely | ✓ | NCCMA epbc |
| *Hirundapus caudacutus* | White-throated needletail | | P | May | | EPBC |

| Species name | Common name | EPBC status | Migratory (EPBC) | Presence | FFG listing* | Source** |
|---|---|---|---|---|---|---|
| *Lathamus discolor* | Swift Parrot | E | | Likely | ✓ | EPBC |
| *Leipoa ocellata* | Malleefowl | V | | Likely | ✓ | EPBC |
| *Merops ornatus* | Rainbow bee-eater | | P | Known | | NCCMA EPBC |
| *Oxyura australis* | Blue-billed duck | | | Known | ✓ | NCCMA |
| *Pedionomus torquatus* | Plains-wanderer | V | | Likely | ✓ | EPBC |
| *Plegadis falcinellus* | Glossy ibis | | P | Known | | NCCMA |
| *Polytelis swainsonii* | Superb parrot | V | | May | ✓ | EPBC |
| *Pomatostomus temporalis temporalis* | Grey-crowned babbler | | | Known | ✓ | NCCMA DSE |
| *Rostratula australis* | Australian painted snipe | V | | May | ✓ | EPBC |
| *Rostratula benghalensis s. lat.* | Painted snipe | | P | May | | EPBC |
| *Stictonetta naevosa* | Freckled duck | | | Known | ✓ | NCCMA |
| *Tringa nebularia* | Common greenshank | | P | Known | | NCCMA |
| *Xanthomyza phrygia* | Regent honeyeater | E | P | May | ✓ | EPBC |
| **Mammals** | | | | | | |
| *Nyctophilus timoriensis (South-eastern form)* | Greater long-eared bat | V | | May | ✓ | EPBC |

V Vulnerable
E Endangered
CE Critically endangered
* FFG Listing under the provisions of Part 3 of the *Flora and Fauna Guarantee Act 1988*
** Source EPBC: EPBC Act, Protected Matters Search Tool website.
DSE: Department of Sustainability and Environment, Biodiversity Interactive Map website.
NCCMA: NCCMA (2010). Lake Yando Environmental Watering Plan. Prepared for the Northern Victoria Irrigation Renewal Project, North Central Catchment Management Authority, Huntly, Victoria.

# Appendix 6: Risk assessment framework

## *Risk likelihood rating*

| | |
|---|---|
| Almost certain | Is expected to occur in most circumstances |
| Likely | Will probably occur in most circumstances |
| Possible | Could occur at some time |
| Unlikely | Not expected to occur |
| Rare | May occur in exceptional circumstances only |

## *Risk consequence rating*

| | |
|---|---|
| Critical | Major widespread loss of environmental amenity & progressive irrecoverable environmental damage |
| Major | Severe loss of environmental amenity and danger of continuing environmental damage |
| Moderate | Isolated but significant instances of environmental damage that might be reversed with intensive efforts |
| Minor | Minor instances of environmental damage that could be reversed |
| Insignificant | No environmental damage |

## *Risk analysis matrix*

| LIKELIHOOD | CONSEQUENCE | | | | |
|---|---|---|---|---|---|
| | Insignificant | Minor | Moderate | Major | Critical |
| Almost certain | Low | Medium | High | Severe | Severe |
| Likely | Low | Medium | Medium | High | Severe |
| Possible | Low | Low | Medium | High | Severe |
| Unlikely | Low | Low | Low | Medium | High |
| Rare | Low | Low | Low | Medium | High |