SECTION 5

Northern region

5.1 Northern region overview 157

5.2 Victorian Murray system 167
5.2.1 Barmah Forest 168
5.2.2 Gunbower Creek and Forest 173
5.2.3 Central Murray wetlands 180
5.2.4 Hattah Lakes 186
5.2.5 Lower Murray wetlands 190
5.2.6 Lindsay, Mulcra and Wallpolla islands 197

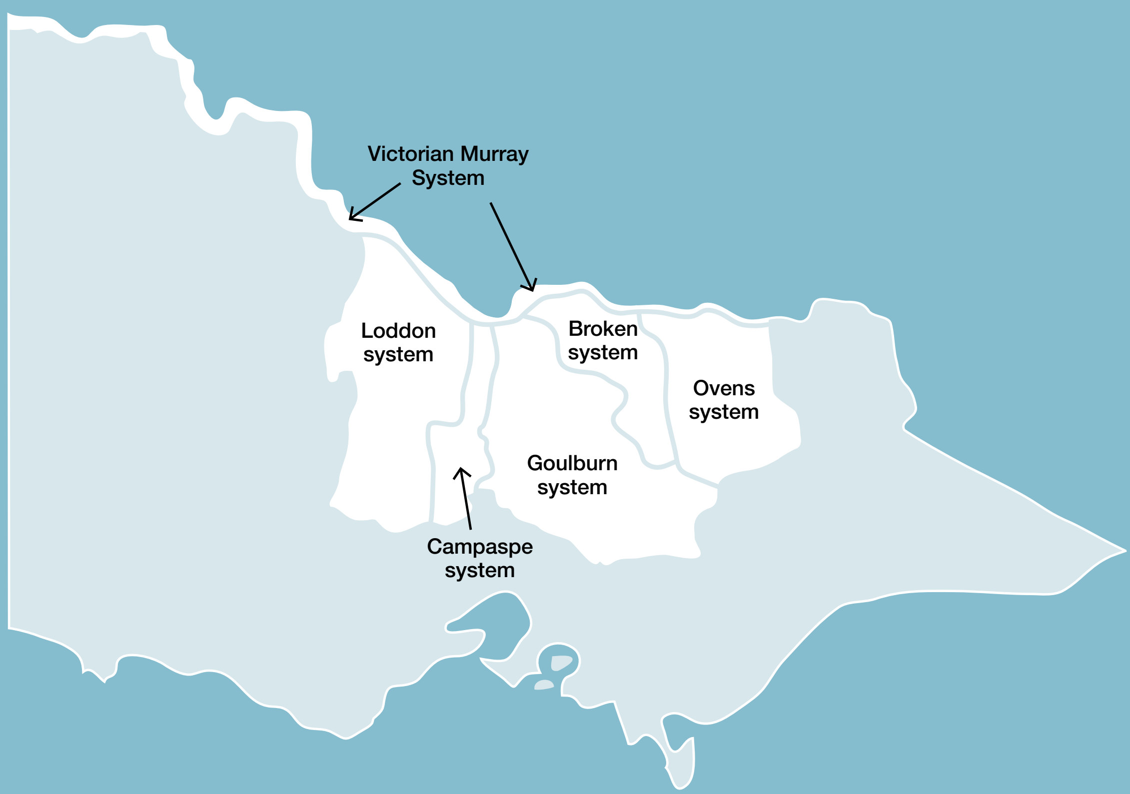
5.3 Ovens system 203

5.4 Goulburn system 208
5.4.1 Goulburn River 209
5.4.2 Goulburn wetlands 216

5.5 Broken system 219
5.5.1 Broken River and upper Broken Creek 221
5.5.2 Lower Broken Creek 224
5.5.3 Broken wetlands 228

5.6 Campaspe system 231
5.6.1 Campaspe River 232
5.6.2 Coliban River 237

5.7 Loddon system 240
5.7.1 Loddon River system (including Tullaroop, Serpentine and Pyramid creeks) 241
5.7.2 Boort wetlands 250
5.7.3 Birch Creek 253



5.1 Northern region overview

The northern region has six river systems, four major floodplain sites and many wetlands that can receive water for the environment. The Broken, Campaspe, Goulburn, Loddon and Ovens river systems are tributaries of the River Murray. The four major floodplain sites along the River Murray corridor are Barmah Forest, Gunbower Forest, Hattah Lakes and Lindsay, Mulcra and Wallpolla islands. The other wetlands are distributed across the Broken, Goulburn, Loddon and Murray floodplains. The rivers and wetlands in the northern region are managed by the North East, Goulburn Broken, North Central and Mallee CMAs.

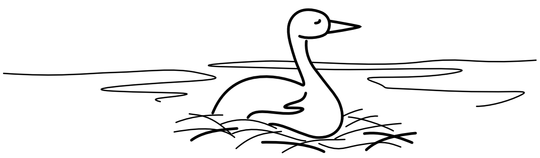
Many of the water systems in the northern region are connected through infrastructure (such as Goulburn Weir and the Waranga Western Channel), which allows water to be physically delivered from the Goulburn River to the Loddon and Campaspe systems. Water trading also enables transfers of allocation between systems. Within the limitations of each mechanism, water for the environment can be moved between systems for delivery to environmental sites across northern Victoria, although most water for the environment is usually used to provide benefits in the systems in which the water is held.

Environmental values, recent conditions, environmental watering objectives and planned actions for each system in the northern region are presented in the system sections that follow.

Traditional Owners in the northern region

Traditional Owners and their Nations in the northern region continue to have a deep connection to the region's rivers, wetlands and floodplains.

The Traditional Owner groups in and around northern Victoria include Barapa Barapa, Dhudhuroa, Latji Latji, Ngintait, Nyeri Nyeri, Taungurung, Tati Tati, Wadi Wadi, Wamba Wemba, Waywurru, Weki Weki, Yorta Yorta and Yaithmathang. The Dja Dja Wurrung Clans Aboriginal Corporation, First People of the Millewa-Mallee Aboriginal Corporation (representing Latji Latji, Nyeri Nyeri, Ngintait), Taungurung Land and Waters Council Aboriginal Corporation and Yorta Yorta Nation Aboriginal Corporation are Registered Aboriginal Parties under the *Aboriginal Heritage Act 2006*.



Three formal agreements with Traditional Owners in the northern region are in place:

- In 2013, the Dja Dja Wurrung entered into a recognition and settlement agreement under the *Traditional Owner Settlement Act 2010* in Victoria. Under the agreement, Dja Dja Wurrung has rights to access and use water for traditional purposes, providing the take of water does not affect other parties.
- In 2004, the Victorian Government entered into a cooperative management agreement with the Yorta Yorta to improve collaboration in the management of their Country including Barmah State Forest and reserves along the Goulburn River.
- In 2018, the Victorian Government, the Taungurung Clans Aboriginal Corporation and the Taungurung Traditional Owner group signed agreements under the *Traditional Owner Settlement Act 2010* and related legislation.

In recognition of the cultural importance of water for Aboriginal people and their traditional ecological knowledge, waterway managers across the northern region are working with Traditional Owners to involve them in management of environmental flows. In 2019–20, this may include the following initiatives:

- The first-ever delivery of water for the environment to Horseshoe Lagoon, Kanyapella Basin and Loch Garry, which are important to Taungurung (Horseshoe Lagoon) and Yorta Yorta (Kanyapella Basin and Loch Garry) people respectively. The Taungurung Land & Water Council and the Yorta Yorta Nation Aboriginal Corporation have been involved in writing the environmental water management plans for the wetlands and setting ecological objectives. Taungurung people may also be involved in delivering water to Horseshoe Lagoon, which is significant as many Taungurung people live and work off-Country.

- A partnership between the Barapa Barapa people, Wamba Wemba people and North Central CMA to involve Traditional Owners in the planning, monitoring and reporting of watering in Guttrum Forest, as part of the ongoing Barapa Barapa Wamba Wemba Water for Country project.
- Collaboration between Goulburn Broken CMA and Yorta Yorta people, to ensure cultural values are considered in watering decisions. This has led to Yorta Yorta people being involved in developing plans and objectives for a number of sites in the Goulburn Broken catchment. Examples include in Barmah Forest, where drought refuges may be watered to protect the broad-shelled turtle, which is an important totem species for Yorta Yorta people; and Loch Gary, where a proposed wetland fill in autumn 2020 would support waterbird habitat, which has been identified as an ecological objective by the Yorta Yorta people.
- Input of Wadi Wadi Traditional Owners into planned watering of wetlands near Robinvale in the Mallee CMA region.

Engagement

Seasonal watering proposals are informed by longer-term regional catchment strategies, regional waterway strategies, relevant technical studies (such as environmental flow studies and environmental water management plans), as well as by input from program partners and stakeholders. The strategies and technical reports collectively describe a range of cultural, economic, environmental, social and Traditional Owner perspectives and longer-term integrated catchment and waterway management objectives that influence environmental watering actions and priorities for the coming year

The International Association for Public Participation's Public Participation Spectrum (IAP2 Spectrum) has been used to categorise the levels of participation of stakeholders involved in the environmental watering planning process. Table 5.1.1 shows the IAP2 Spectrum categories and participation goals.

Table 5.1.1 IAP2 Spectrum categories and participation goals[1]

Engagement category	Engagement goal
Inform	Provide balanced and objective information to assist understanding, alternatives, opportunities and/or solutions
Consult	Obtain feedback on analysis, alternatives and/or decisions
Involve	Work directly throughout a process to ensure that concerns and aspirations are consistently understood and considered
Collaborate	Partner in each aspect of the decision including the development of alternatives and the identification of the preferred solution
Empower	Place final decision making in the hands of the stakeholder

1 The VEWH has the permission of the International Association for Public Participation to reproduce the IAP2 Spectrum.

Tables 5.1.2 to 5.1.5 show the partners, stakeholder organisations and individuals with which the Goulburn Broken, North Central, North East and Mallee CMAs engaged when preparing seasonal watering proposals. This includes engagement conducted as part of developing seasonal watering proposals as well as engagement during the preparation of key foundational documents that directly informed the proposals. The tables also show the level of engagement, based on the Goulburn Broken, North Central, North East and Mallee CMAs' interpretation of the IAP2 Spectrum.

The level of engagement differs between organisations and between systems, due to the complexity of management arrangements and individual organisation's responsibilities for each system. For example, under a cooperative management agreement between Yorta Yorta Nation Aboriginal Corporation and the State of Victoria, the Yorta Yorta Traditional Owner Land Management Board is legally required to be involved in decisions about the management of Barmah Forest. Therefore, the Yorta Yorta Traditional Owner Land Management Board is listed as a program partner that collaborates with Goulburn Broken CMA on the planning and delivery of water for the environment releases at Barmah Forest. Elsewhere in the northern region, Traditional Owners are consulted or informed about environmental watering and their recommendations are included in planning. Waterway managers are working with Traditional Owner groups in their regions to strengthen their involvement in water for the environment planning.

Table 5.1.2 Partners and stakeholders engaged by Goulburn Broken CMA in developing seasonal watering proposals for Barmah Forest and the Goulburn and Broken systems and other key foundation documents that have directly informed the proposals

	Barmah Forest	Goulburn River	Goulburn wetlands and Broken wetlands	Broken River and upper Broken Creek	Lower Broken Creek
Community groups and environment groups		• Goulburn Valley Environment Group	• Goulburn Murray Landcare Network • Goulburn Valley Environment Group • Kinnairds Wetland Advisory Committee • Turtles Australia	• Goulburn Valley Environment Group	• Broken Environmental Water Advisory Group
Landholders/ farmers		• Individual landholders who are on the Goulburn Environmental Water Advisory Group	• Individual landholders	• Individual landholders	• Individual landholders who are on the Broken Environmental Water Advisory Group
Program partners	• Commonwealth Environmental Water Office • Department of Environment, Land, Water and Planning • Goulburn-Murray Water • Murray-Darling Basin Authority • New South Wales Office of Environment and Heritage • Parks Victoria • Victorian Environmental Water Holder • Yorta Yorta Traditional Owner Land Management Board	• Commonwealth Environmental Water Office • Goulburn-Murray Water • Murray-Darling Basin Authority • Parks Victoria • Victorian Environmental Water Holder	• Department of Environment, Land Water and Planning • Goulburn-Murray Water • Moira Shire • Parks Victoria	• Commonwealth Environmental Water Office • Goulburn-Murray Water • Parks Victoria • Victorian Environmental Water Holder	• Commonwealth Environmental Water Office • Goulburn-Murray Water • Parks Victoria • Victorian Environmental Water Holder
Recreational users		• A local ecotourism operator • Trellys Fishing and Hunting	• Field and Game Australia • Trellys Fishing and Hunting		• Nathalia Angling Club Numurkah Angling Club
Traditional Owners		• Taungurung Land and Waters Council • Yorta Yorta Nation Aboriginal Corporation	• Taungurung Land and Waters Council • Yorta Yorta Nation Aboriginal Corporation	• Taungurung Land and Waters Council • Yorta Yorta Nation Aboriginal Corporation	• Taungurung Land and Waters Council • Yorta Yorta Nation Aboriginal Corporation

Key: Inform · Consult · Involve · Collaborate · Empower

Table 5.1.3 Partners and stakeholders engaged by North Central CMA in developing seasonal watering proposals for Gunbower Creek and Forest, the central Murray wetlands, the Loddon and Campaspe systems and other key foundation documents that have directly informed the proposals

	Gunbower Creek and Forest	Central Murray wetlands and Boort wetlands	Campaspe River	Coliban River	Loddon River	Birch Creek
Community groups and environment groups	• BirdLife Australia • Gunbower Landcare Group					
Government agencies						• Parks Victoria
Landholders/ farmers	• Individual community members • Individual irrigators	• Individual community members • Individual landholders	• Individual Landholders	• Individual Landholders	• Individual Landholders	• Individual Landholders
Local government	• Campaspe Shire Council • Gannawarra Shire Council					
Local businesses	• Forestry businesses • Apiary licensees	• Forestry businesses • Apiary licensees				
Program partners	• Commonwealth Environmental Water Office • Department of Environment, Land, Water and Planning • Forestry Corporation of New South Wales • Goulburn-Murray Water • Murray-Darling Basin Authority • Parks Victoria • VicForests • Victorian Environmental Water Holder	• Campaspe Shire Council • Commonwealth Environmental Water Office • Department of Environment, Land, Water and Planning • Forestry Corporation of New South Wales • Goulburn-Murray Water • Loddon Shire Council • Murray-Darling Basin Authority • Parks Victoria • Swan Hill Rural City Council • VicForests • Victorian Environmental Water Holder	• Commonwealth Environmental Water Office • Goulburn-Murray Water • Victorian Environmental Water Holder • Department of Environment, Land, Water and Planning	• Coliban Water • Commonwealth Environmental Water Office • Victorian Environmental Water Holder • Department of Environment, Land, Water and Planning	• Commonwealth Environmental Water Office • Goulburn-Murray Water • Victorian Environmental Water Holder • Department of Environment, Land, Water and Planning	• Goulburn-Murray Water • Victorian Environmental Water Holder • Department of Environment, Land, Water and Planning

Table 5.1.3 Partners and stakeholders engaged by North Central CMA in developing seasonal watering proposals for Gunbower Creek and Forest, the central Murray wetlands, the Loddon and Campaspe systems and other key foundation documents that have directly informed the proposals *continued...*

	Gunbower Creek and Forest	Central Murray wetlands and Boort wetlands	Campaspe River	Coliban River	Loddon River	Birch Creek
Recreational users	• Field and Game Australia • Gateway to Gannawarra Visitor Centre	• BirdLife Australia • Field and Game Australia	• Local canoe clubs • Victorian Game Authority	• Local canoe clubs • Victorian Game Authority	• Field and Game Australia • VRFish	
Technical specialists	• Vegetation, fish and bird ecologists on the Gunbower Technical Advisory Group					
Traditional Owners	• Barapa Barapa Traditional Owners • Yorta Yorta Nation Aboriginal Corporation	• Barapa Barapa Traditional Owners • Dja Dja Wurrung Clans Aboriginal Corporation • Wamba Wemba Traditional Owners • Yorta Yorta Nation Aboriginal Corporation	• Dja Dja Wurrung Clans Aboriginal Corporation • Taungurung Land and Waters Council • Yorta Yorta Nation Aboriginal Corporation	• Dja Dja Wurrung Clans Aboriginal Corporation	• Barapa Barapa Traditional Owners • Dja Dja Wurrung Clans Aboriginal Corporation • Wamba Wemba Traditional Owners	• Dja Dja Wurrung Clans Aboriginal Corporation

Key: Inform Consult Involve Collaborate Empower

Table 5.1.4 Partners and stakeholders engaged by Mallee CMA in developing seasonal watering proposals for Hattah Lakes, the lower Murray wetlands and Lindsay, Mulcra and Wallpolla islands and other key foundation documents that have directly informed the proposals

	Hattah Lakes	Lower Murray wetlands	Lindsay, Mulcra and Wallpolla islands
Community groups and environment groups		• Mid-Murray Field Naturalists Incorporated Association	
Landholders/ farmers	• Individual landholders		
Local businesses	• Individual small business owners	• Mallee Tours • Mildura Information Centre • Murray Offroad Adventures • Sunraysia Apiarist Association • Visit Mildura • Wildside Outdoors	• Mallee Tours • Mildura Information Centre • Murray Offroad Adventures • Sunraysia Apiarist Association • Visit Mildura • Wildside Outdoors
Local government	• Mildura Rural City Council	• Mildura Rural City Council	• Mildura Rural City Council
Program partners	• Commonwealth Environmental Water Office • Murray-Darling Basin Authority • Parks Victoria • Victorian Environmental Water Holder	• Murray-Darling Basin Authority • Parks Victoria • Victorian Environmental Water Holder	• Commonwealth Environmental Water Office • Murray-Darling Basin Authority • Parks Victoria • Victorian Environmental Water Holder
	• Department of Environment, Land, Water and Planning	• Department of Environment, Land, Water and Planning	• Department of Environment, Land, Water and Planning
	• Goulburn-Murray Water	• Goulburn-Murray Water	
Recreational users	• Mildura Birdlife Club • Sunraysia Bushwalkers	• Mildura Birdlife Club • Sunraysia Bushwalkers	• Mildura Birdlife Club • Sunraysia Bushwalkers
Traditional Owners	• Latje Latje Traditional Owners • Munutunga Traditional Owners • Tati Tati Traditional Owners • Wadi Wadi Traditional Owners	• Wadi Wadi Traditional Owners and the broader Aboriginal community	• First People of the Millewa-Mallee Aboriginal Corporation

Key: Inform Consult Involve Collaborate Empower

Table 5.1.5 Partners and stakeholders engaged by North East CMA in developing the seasonal watering proposal for the Ovens system and other key foundation documents that have directly informed the proposal

Ovens system	
Community groups and environment groups	• Wangaratta Sustainability Network
Government agencies	• Arthur Rylah Institute • Victorian Fisheries Authority
Landholders/ farmers	• Catholic Education Department – Sandhurst Diocese
Local government	• Rural City of Wangaratta
Program partners	• Commonwealth Environmental Water Office • Goulburn-Murray Water • Victorian Environmental Water Holder
Traditional Owners	• Taungurung Land and Waters Council • Yorta Yorta Nation Aboriginal Corporation

Key: Inform Consult Involve Collaborate Empower

Community benefits from environmental watering

As described in subsection 1.1.1, environmental flows that improve the health of rivers, wetlands and floodplains also provide benefits to communities, because healthy rivers and wetlands support vibrant and healthy communities.

Environmental outcomes provide direct flow-on cultural, economic, recreational, social and Traditional Owner benefits for communities. In 2019–20, examples in the northern region include:

- supporting Murray cod, golden perch and other recreational fish species in waterways across the region including the Ovens River, Broken River, Goulburn River, Broken Creek, Campaspe River, Gunbower Creek, Loddon River, Pyramid Creek and the Mullaroo and Lindsay rivers
- providing increased opportunities for birdwatching by providing nesting sites, food and habitat for a wide variety of waterbirds in wetlands across the entire northern region
- recreational users and local businesses taking advantage of high water levels in waterways and wetlands (such as Gunbower Creek and Forest, Barmah Forest, the Campaspe River, Hattah Lakes and the lower Murray wetlands) for activities like fishing, boating and canoeing.

Additional opportunities to enhance community benefits can also sometimes be provided by modifying environmental flows, provided environmental outcomes are not compromised. For example, North Central CMA may time a summer fresh in the Campaspe River to occur on the Australia Day long weekend in January 2020, so people camping and picnicking alongside the river can enjoy the Australia Day weekend with additional flows in the river.

The ability of the VEWH and its partners to deliver these benefits will depend on the weather, climate considerations, the available water and the way the system is being operated to deliver water for other purposes.

Integrated catchment management

Altered water regimes are one of many threats to the health of Victoria's waterways. To be effective, planning and releases of water for the environment need to be part of an integrated approach to catchment management. Many of the environmental objectives for the northern region will not be fully met without simultaneously addressing issues such as excessive catchment erosion, barriers to fish movement, high nutrient loads, loss of stream bank vegetation and invasive species, to name just a few issues.

Victorian and Australian government agencies, community groups and private landowners collectively implement a wide range of programs that aim to protect and improve the environmental condition and function of land, soils and waterways throughout Victoria's catchments.

Examples of complementary programs that are likely to support environmental watering outcomes in the northern region include the following:

- Construction of a fish screen at Cohuna Weir on Gunbower Creek by North Central CMA. The fish screen was completed in July 2018 to prevent native fish and larvae in Gunbower Creek entering the number 2 irrigation channel. The Cohuna Weir fish screen is the first screen on a gravity-fed irrigation channel in Australia.
- Fishways built at the Chute, Box Creek regulator, Kerang Weir and Little Murray River in recent years have improved fish passage and supported fish migration between the Loddon and Murray systems.

- A willow removal program at Birch Creek conducted in 2018 is helping to rehabilitate natural geomorphic processes and improve water quality in the system.
- The Caring for the Campaspe project is a collaboration with landholders that focuses on protecting and enhancing riparian and fringing vegetation along the Campaspe River.
- A proposed strategic action plan for Barmah Forest includes the management of invasive animals (such as feral horses) that do significant damage to native vegetation by overgrazing on the floodplain marshes. If implemented, this plan would complement existing grazing exclosure fencing that protects one of the highest-value floodplain marsh wetlands in the forest, Little Rushy Swamp. Broad management of threats (such as grazing by feral horses) is required to recover the health of the Barmah Forest. Fencing extremely high-value areas is a temporary measure to avoid local extinction of species (such as Moira grass) ahead of improved long-term management actions (such as removing feral horses).

For more information about integrated catchment management programs in the northern region, refer to the North East, Goulburn Broken, North Central and Mallee CMAs' regional catchment strategies and regional waterway strategies.

Seasonal outlook 2019–20

Northern Victoria has experienced mostly below-average rainfall and corresponding low levels of inflows into waterways and storages since the start of 2017. Storage levels and overall water availability continued to decline during 2018–19, and environmental watering was modified where required to help conserve water for 2019–20.

Each year on 15 May, the Northern Victoria Resource Manager (NVRM) releases a water availability outlook for northern Victoria for the coming year. These seasonal outlooks are updated monthly once the season begins, and are available at www.nvrm.net.au.

The 2019–20 outlook at 15 May 2019 indicated that early-season allocations are expected to be low in most systems. The opening high-reliability entitlement allocation is forecast to be one percent or zero in the Murray, Goulburn, Loddon, Broken and Bullarook systems under continuing dry to extremely dry conditions. The opening allocations for high-reliability entitlements in the Campaspe system are forecast to be 17 percent. Under ongoing extreme dry to dry scenarios (that is, if inflows are similar to the lowest one to 10 percent of inflows on record), most systems are not expected to reach 50 percent high-reliability allocation in 2019–20. The NVRM has not provided an outlook for low-reliability entitlements, but for planning purposes the VEWH has assumed no allocation against low-reliability entitlements during 2019–20, unless significant rain provides inflows that are in line with above-average to wet climate scenarios.

Carryover into 2019–20 becomes especially critical to meet early-season demands. The VEWH is planning to carry over moderate volumes of water across the northern Victorian systems to meet early-season demands, and it works with the Commonwealth Environmental Water Holder (CEWH) and the Living Murray program to optimise the use of all water for the environment across northern Victoria.

In 2017–18, a large volume (around 314,000 ML) of River Murray Increased Flows (RMIF) water was released from the Snowy storages because of Snowy Hydro releases for electricity generation. A small portion of this RMIF was used in 2017–18 and a large amount was used in 2018–19 for environmental outcomes in the Murray system. Around one-sixth (50,000 ML) was intentionally set aside to carry over into 2019–20 to meet environmental demands in Victoria, NSW and SA as a reserve to mitigate against ongoing dry conditions. This reserve will be critical to maintaining the health of the River Murray system in 2019–20, especially if winter and spring are dry.

Demands for water for the environment in northern Victoria are usually highest in winter and spring. Most systems in northern Victoria have lower demands under drought to dry scenarios, where the focus is on maintaining condition, and operational water deliveries meet many of the minimum-flow requirements in rivers. Environmental demands generally increase under wetter conditions, because extra water is needed to extend the duration of natural high flows and connect additional floodplain habitats to optimise environmental outcomes during these important productive periods.

If dry conditions continue through winter and spring 2019, water for the environment will be used to provide winter flows in creeks and rivers to maintain habitat, particularly for native fish. Some wetlands are also likely to be watered in winter/spring 2019, to provide some habitat in the landscape for waterbirds and turtles and to ensure the maximum tolerable dry periods for wetland plant communities are not exceeded. Different wetlands are watered each year during prolonged dry periods, to ensure some water is present in the landscape for mobile animals and to prevent critical declines in the condition of vegetation communities at priority wetlands. This approach is important, to protect the outcomes of previous environmental watering actions and to prevent declines that may be difficult to recover in the future.

Even under dry conditions, higher river flows may occur, due to the operational delivery of water. Operational deliveries are water released from upstream to meet a downstream demand. Depending on their magnitude and timing, operational flows in some systems may support environmental outcomes or cause environmental harm. While program partners work closely with river operators to achieve positive environmental outcomes year-round, the nature of downstream demands means this is not always possible.

In 2019–20, high operational flows are expected under some scenarios in the River Murray and the Goulburn River. For example, operational transfers of water from Hume Reservoir to the lower Murray in spring may create an opportunity to piggyback environmental flows above choke capacity through the Barmah–Millewa Forest. This would help achieve environmental outcomes in the forest that would not be achievable with environmental flows alone. In the Goulburn River, the potential for high summer operational flows (inter-valley transfers) increases the need for environmental watering actions in winter and spring that may improve riparian vegetation and bank stability and help protect the river from summer operational flows.

Large rainfall events may result in unregulated flows that meet or exceed many of the flow targets for water for the environment in downstream waterways. Unregulated flows can reduce the amount of water for the environment that needs to be delivered to meet the highest-priority objectives, allowing additional watering actions during the year. However, if spills from storages occur, some or all unused water carried over from 2018–19 may be deducted from water for the environment accounts.

What is the *Basin Plan 2012*?

Northern Victoria is a part of the Murray-Darling Basin and deliveries of water for the environment in the northern region are subject to the requirements of the *Basin Plan 2012*, also known as the Murray-Darling Basin Plan or just the Basin Plan. The Murray-Darling Basin Authority (MDBA) developed the Basin Plan under the *Commonwealth Water Act 2007* and it became law in November 2012. The Basin Plan sets legal limits on the amount of water that can be taken from the Murray-Darling Basin's surface and groundwater resources. Chapter 8 of the Basin Plan also sets out a high-level environmental watering plan, which defines environmental objectives to protect, restore and build the resilience of water-dependent ecosystems and their associated functions. The VEWH's environmental planning and delivery is consistent with the requirements of the Basin Plan. The potential environmental watering outlined in sections 4 and 5 of this seasonal watering plan fulfil Victoria's obligations to identify annual environmental watering priorities for Victoria's water resource areas under section 8.26 of the *Basin Plan 2012*.

What is River Murray Increased Flows (RMIF)?

River Murray Increased Flows (RMIF) is water for the environment that has been recovered as part of the Snowy Water Initiative, established in 2002 to address environmental impacts associated with the operation of the Snowy Mountains Scheme. RMIF is stored in Snowy Hydro Limited’s storages and released to maintain and improve environmental values in the River Murray. RMIF becomes available when:

- Snowy Hydro Limited release more than their nominated annual release volume, as part of their power generation operations
- Environmental water managers request additional RMIF be made available when volumes in River Murray storages exceed specified limits.

The call for and use of RMIF is coordinated by the Southern Connected Basin Environmental Watering Committee, and it must be authorised by both the VEWH and NSW Office of Environment and Heritage.

Northern Victoria and the southern Murray-Darling Basin

Rivers, creeks and floodplains in northern Victoria form part of the southern-connected Murray-Darling Basin. Water flows directly from the Victorian rivers and floodplains into the River Murray, which means that environmental flows delivered in northern Victorian systems can achieve ecological objectives at multiple sites throughout the Murray-Darling Basin. For example, water for the environment delivered in the Goulburn River flows into the River Murray and can be shepherded all the way to the Lower Lakes and Coorong in South Australia, providing environmental outcomes at Gunbower Forest, Hattah Lakes, Lindsay Island and the Chowilla floodplain along the way.

The Basin Plan 2012 and the 2014 *Basin-wide environmental watering strategy* guide the long-term planning of water for the environment in the Murray-Darling Basin. Under the Basin Plan, environmental objectives are met by achieving outcomes for connectivity, native vegetation, waterbirds and native fish.

Objectives and outcomes under the Basin Plan reflect local site- and state-based objectives, though site-based objectives are often broader in scope and specifically cover additional values (such as frogs, turtle, waterbugs and physical processes like sediment movement). Watering actions that support Basin Plan outcomes have significant benefits for many other species that rely on the surrounding landscape (such as squirrel gliders living along the lower Campaspe River or flocks of regent parrots moving into the Hattah Lakes floodplain after watering).

The VEWH coordinates its activities with other environmental water holders in northern Victoria, NSW and SA to achieve environmental outcomes at the southern-connected Murray-Darling Basin scale. Collaborative planning focuses on how upstream and downstream objectives align and how the broader operation of the River Murray system can help support environmental outcomes.

Annual planning is documented in basin annual environmental watering priorities (by MDBA under the Basin Plan), in annual portfolio management plans (by the Commonwealth Environmental Water Office, and in the VEWH's annual seasonal watering plan (that is, this document). In Victoria, all water for the environment must be delivered in line with the VEWH's seasonal watering plan, meaning coordination during annual planning is fundamental to successful basin-scale outcomes.

All environmental water holders in the Murray-Darling Basin are placing an increased emphasis on coordinating water deliveries to achieve landscape-scale environmental outcomes. Examples include:

- delivering a winter fresh in the Goulburn River, which subsequently passed through to the Lower Lakes in South Australia and through the barrages to the Coorong to trigger upstream migration of fish (such as lamprey)
- efficient water use meant that 78 percent of the flows delivered to Gunbower Forest in 2018–19 were from return flows that had been delivered upstream in the Campaspe and Goulburn rivers (for environmental purposes) then reused in Gunbower Forest, providing benefits not only to those rivers but also to the forest and River Murray as well.

The VEWH holds Victorian environmental entitlements for water recovered under interstate projects and agreements — Living Murray and RMIF entitlements — and these require coordinated decision-making about where they are used. The primary objective of Living Murray entitlements is to support Murray icon sites, which include the Barmah Forest, Gunbower Forest, Hattah Lakes and the Lindsay–Mulcra–Wallpolla islands in Victoria. RMIF also support environmental objectives along the Murray system in Victoria, NSW and SA. Recommendations for the coordinated use of Living Murray allocation and RMIF are made by the Southern Connected Basin Environmental Watering Committee.

The VEWH partners with the Commonwealth Environmental Water Office to optimise the benefits of water for the environment held by the CEWH and delivered in Victoria. Delivery of the Living Murray's and Commonwealth's environmental Water Holdings, to meet Victorian environmental watering objectives, is included in relevant system sections in the following pages of this document.

Water for the environment delivered through northern Victorian waterways can often be reused to achieve further environmental benefits downstream. If return flows are not reused at Victorian environmental sites, VEWH, Living Murray and CEWH return flows continue to flow across the border to South Australia where they will be used to provide environmental benefits along the River Murray and in the Coorong, Lower Lakes and Murray Mouth area.

The VEWH may also order, or authorise waterway managers to order, Living Murray and Commonwealth water for the environment for environmental outcomes at downstream (non-Victorian) sites. As well, the VEWH may order water for delivery in the Murray system to non-Victorian sites under river operating rules that help improve environmental outcomes while maintaining the reliability of entitlements for all water users. In previous years, this has included deliveries to the Murray from the lower Darling, orders for delivery from Lake Victoria and orders for delivery to the River Murray itself.

Risk management

During the development of the seasonal watering proposals for the northern region systems, environmental watering program partners held workshops to assess risks associated with potential environmental watering actions for 2019–20 and identify appropriate mitigating strategies. Risks and mitigating actions are continually assessed by program partners throughout the year (see subsection 1.3.6).

5.2 Victorian Murray system

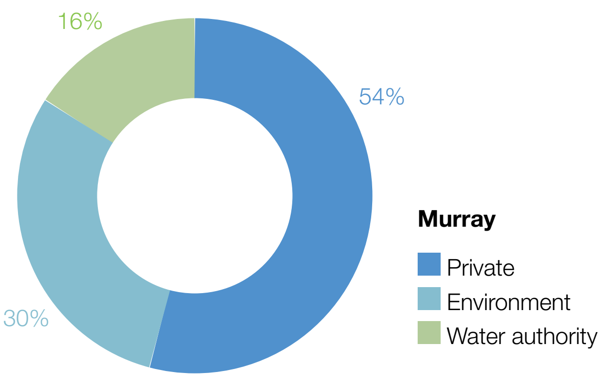
Waterway managers – Goulburn Broken, Mallee and North Central catchment management authorities

Storage managers – Goulburn-Murray Water, Lower Murray Water, Murray-Darling Basin Authority (River Murray Operations), SA Water

Environmental water holders – Victorian Environmental Water Holder (including the Living Murray program), Commonwealth Environmental Water Holder

Did you know …?

The Murray is Australia's longest and most iconic river and supports freshwater, floodplain, wetland and estuarine environments of national and international significance. This includes Australia's (and the world's!) largest river redgum forest at Barmah, wetlands listed under the Convention on Wetlands of International Importance (the Ramsar Convention), and Australia's largest freshwater fish species, the Murray cod.



Proportion of water entitlements in the Murray basin held by private users, water corporations or environmental water holders at 30 June 2018.

Top: Hattah Lakes, by Mallee CMA
Centre: Brolga courting dance, McDonald Swamp, by North Central CMA
Above: Black winged stints flying over Lake Hawthorn, Mallee CMA

The Victorian Murray system contains many significant floodplains and wetland systems covering the Goulburn Broken, North Central and Mallee CMA areas. The Barmah Forest, Kerang wetlands and Hattah Lakes are internationally significant, Ramsar-listed sites due to the abundance and range of waterbird species that use them. Many other wetlands in the system are either nationally or regionally significant.

Water for the environment can be supplied to the Victorian Murray system from a range of sources. These include entitlements held by the VEWH, which includes those held on behalf of the Living Murray program and River Murray Increased Flows portfolios, and the Commonwealth Environmental Water Holder; reuse of return flows; and in some instances use of operational water en route. The source of the water and the ability to deliver all watering actions will depend on water availability, water commitments by other environmental water holders and operational requirements. As a result, the following Victorian Murray system sections do not specify the expected availability of water for the environment.

5.2.1 Barmah Forest

System overview

The Barmah–Millewa Forest covers 66,000 ha and spans the NSW and Victorian borders between the townships of Tocumwal, Deniliquin and Echuca (Figure 5.2.1). It is an internationally significant, Ramsar-listed wetland due to its outstanding natural values, and it is one of six icon sites for environmental outcomes in the Living Murray initiative. The forest's Victorian component is the Barmah National Park and part of the River Murray Reserve, covering 28,500 ha of forest and wetlands.

Flooding in the Barmah–Millewa Forest depends on flows in the River Murray. A natural narrowing of the river (known as the Barmah choke) restricts flow and results in overbank flooding when flows downstream of Yarrawonga Weir exceed the channel's capacity. This restriction influences both the operation of Yarrawonga Weir and the upper limit of environmental flows that can be delivered to the forests.

The delivery of irrigation water during summer and autumn is managed to minimise unseasonal flooding of the forest. Regulators along the River Murray remain closed during summer and autumn to restrict flow through low-lying flood runners. The delivery of water to Barmah Forest is also limited by an imposed flow constraint downstream of Yarrawonga Weir to prevent flooding of private land. The current constraint limits releases to a maximum of 18,000 ML per day until the end of September (with potentially affected landholder support) and to 15,000 ML per day for the rest of the year. To overcome this constraint, most environmental flows are directed into Barmah and Millewa forests via regulators rather than overbank flows. It is currently not possible to achieve the desired flooding depth and duration for floodplain marsh vegetation in both forests at the same time without natural flooding.

Water management at Barmah–Millewa Forest seeks to build on unregulated flows and the delivery of consumptive and operational water en route to optimise environmental outcomes when possible. As Barmah–Millewa Forest is located towards the upper reaches of the regulated portion of the River Murray, water for the environment delivered to the forest can often be used again at sites further downstream, as part of multi-site watering events.

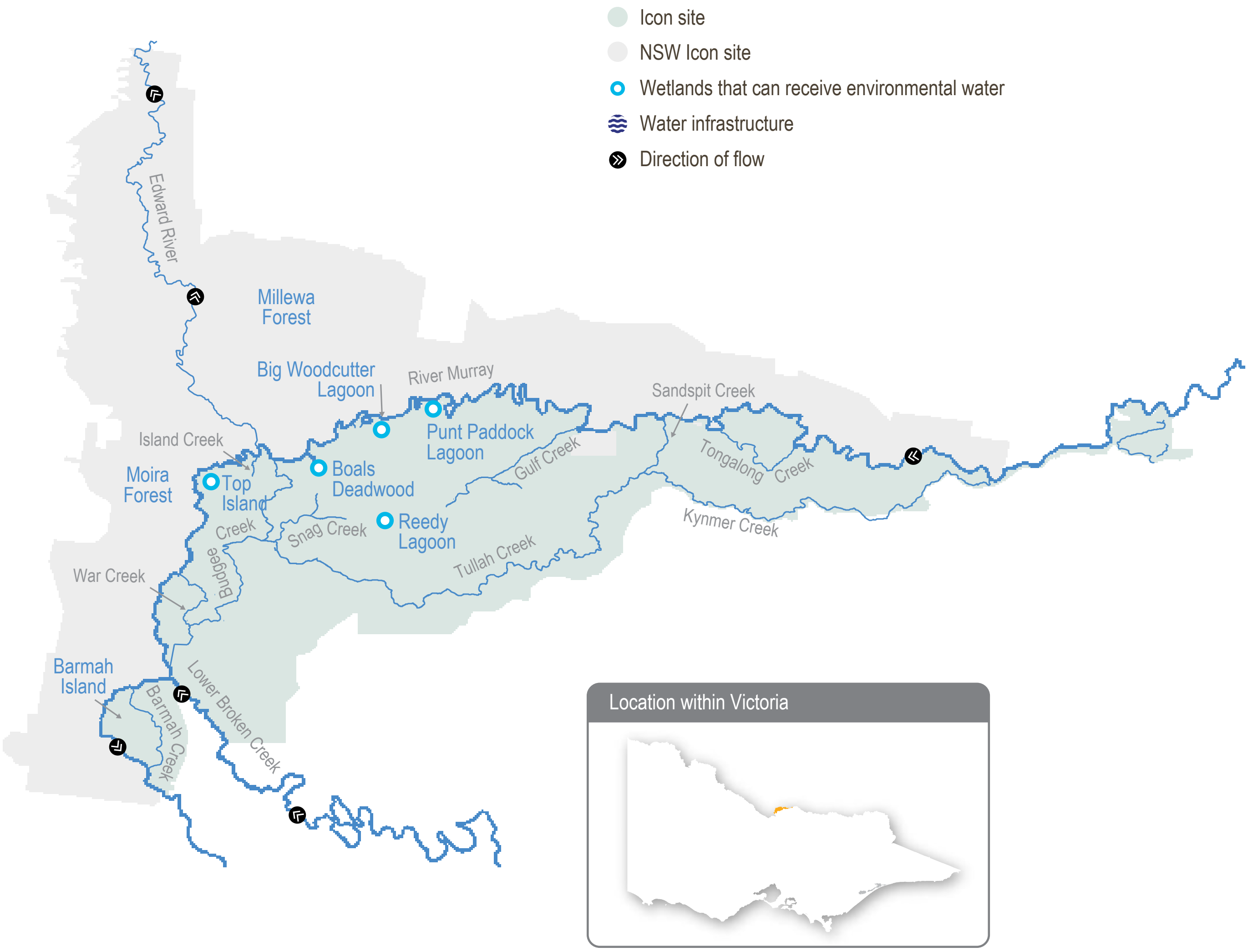
Environmental values

The Barmah–Millewa Forest is the largest river red gum forest in Australia and the most-intact freshwater floodplain system along the River Murray. The forest supports important floodplain vegetation communities including the threatened Moira grass plains and is a significant feeding and breeding site for waterbirds including bitterns, ibis, egrets, spoonbills and night herons. Significant populations of native fish, frogs and turtles also live in the forest's waterways. Barmah Forest is known to support 74 plant and animal species protected under state and national legislation.

Environmental objectives in the Barmah Forest

Provide habitat for native fish and increase the population
Maintain or increase the habitat available for frogs
Enable nutrient cycling (particularly carbon) between the floodplain and river through connectivity
Maintain or increase the habitat available for turtles including the broad-shelled turtle
Enhance the health of river red gum communities and aquatic vegetation in the wetlands and watercourses and on the floodplain Promote the growth of floodplain marsh vegetation communities, particularly the extent of Moira grass growing in these areas
Provide feeding and nesting habitat for the successful recruitment of colonial nesting waterbirds
Provide early-season flushing of the lower floodplain to cycle nutrients during cooler conditions and reduce the risk of poor water quality events in summer

Figure 5.2.1 Barmah Forest



Recent conditions

Forest regulators were opened in July 2018 to allow water to pass through Barmah Forest while the flow in the River Murray was below channel capacity. From September 2018, the volume of operational transfers between Hume Reservoir and Lake Victoria increased and exceeded the channel capacity. These operational transfers caused sustained low-level flooding of the Barmah floodplain. Water for the environment was released in November and December 2018 to enhance the low-level flooding and optimise environmental outcomes triggered by the operational transfers. All flows reduced in late December 2018, and the forest dried out over the rest of summer and autumn.

Around 30 percent of the Barmah floodplain was inundated in spring, resulting in an excellent vegetation response for wetland plants in the shallow freshwater marshlands. Exceptional growth and flowering of Moira grass was recorded, and it was observed to grow in parts of its former range where it has not been recorded for many years. This was an important outcome for a species that has suffered a 90 percent decline in extent since 1930.

Waterbirds also responded to the spring/summer flood. Many species were observed breeding or calling throughout the wetlands including Australasian and little bitterns, and relatively small numbers of colonial nesting waterbirds (such as cormorants, ibis and night herons) also bred. In most years, additional environmental flows are provided during summer to help birds complete their breeding, but this was not required in 2018–19 due to the relatively low numbers of colonial waterbird nests.

Most of the operational flows in spring 2018 were directed through Barmah Forest to optimise the transfers to Lake Victoria. As a result, only around five percent of the Millewa Forest floodplain was inundated. Watering low-lying wetlands in Millewa Forest will be the priority objective if overbank environmental flows occur in 2019–20.

Scope of environmental watering

Table 5.2.1 describes the potential environmental watering actions that may be delivered in 2019–20, their functional watering objectives (that is, the intended physical or biological effect of the watering action) and the longer-term environmental objective they support. Each environmental objective relies on one or more potential environmental watering actions and their associated physical or biological functions.

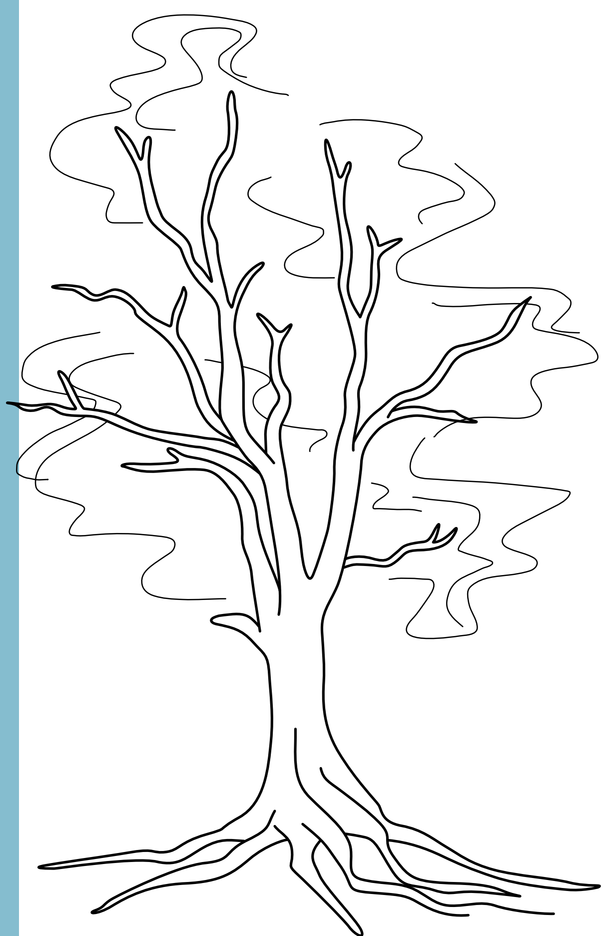


Table 5.2.1 Potential environmental watering actions and objectives for the Barmah Forest

Potential environmental watering action	Functional watering objective	Environmental objective
Winter/spring low flows to various waterways in Barmah Forest (variable flow rates during July to December)	• Provide flow in forest waterways to maintain habitat for native fish and turtles • Facilitate the movement of native fish between floodplain waterways and the river • Remove accumulated organic matter to cycle carbon to the river system and minimise the risk of anoxic blackwater	
Spring/summer freshes (in-channel) in the River Murray channel (up to three events of at least 500 ML/day of variability for eight days during October to December)	• Trigger spawning of native fish species, primarily golden and silver perch	
Spring/summer freshes (drought) to Gulf and Boals creeks (100 ML/day for three to five days as required during November to April)	• Maintain critical drought-refuge areas in Barmah Forest to provide habitat for native fish and turtle populations • Flush drought-refuge pools to maintain water quality	
Spring/summer/autumn low flows to floodplain waterways including Sandspit, Gulf, Big Woodcutter, Boals, Island and Punt Paddock Lagoon (200 ML/day for 30 to 60 days during November to April)[1]	• Provide flows to replenish refuge areas and maintain water quality • Provide flows to replenish permanent waterways, to maintain fish and turtle populations • Maintain connectivity to the river • Remove accumulated organic matter, cycle carbon to the river system and minimise the risk of anoxic blackwater	
Spring inundation of floodplain marshes (variable flow rates up to 18,000 ML/day downstream of Yarrawonga Weir for three months during September to December)[1]	• Provide flooding of sufficient duration to allow the growth of floodplain marsh vegetation in open plains • Provide water to in-forest wetlands and low-lying floodplain areas to create foraging opportunities for birds and increase available habitat for turtles, frogs and small-bodied native fish	
Targeted wetland watering to Boals Deadwood, Reedy Lagoon and Top Island wetlands (200–400 ML/day for four and a half months during September to February)	• Provide a cue to initiate waterbird breeding or maintain a breeding event • Maintain wetland vegetation to provide habitat for colonial nesting and flow-dependent waterbirds	
Autumn/winter low flows in the River Murray (up to 4,000 ML/day downstream of Yarrawonga in May to June)	• Increase water depth in the River Murray channel to provide habitat for large-bodied native fish in the River Murray and unregulated anabranches in Barmah–Millewa Forest	

[1] Likely to target Millewa Forest in 2019–20, unless the Murray–Darling Basin Authority directs operational transfers via Barmah Forest.

Scenario planning

Table 5.2.2 outlines the potential environmental watering and expected water use under a range of planning scenarios.

The ecological objectives at Barmah–Millewa Forest require sustained river flows, peaking with high flows in spring. These are achieved using a suite of small-scale works to improve water management, directing water from the River Murray channel into the forest and then allowing most of it to return to the river for use further downstream. Demands for water for the environment in Barmah Forest vary significantly in response to natural conditions. Under dry conditions, objectives focus on maintaining refuges to sustain fish and turtle populations. Actions to achieve these objectives require relatively small volumes of water to be directed into the forest, and they return relatively small volumes of water back to the river.

Under average or wet conditions, the focus shifts to building resilience in the system by increasing the ecological response to natural flood events. Specific actions may include extending the duration of natural flooding to increase the germination of wetland plants (such as Moira grass) in floodplain marshes or extending watering in river red gum forests to maintain the health of the trees. These actions require large volumes of water to be directed into the forest, with most of it returned to the river.

Water for the environment was delivered in May 2019 and June 2019, to increase native fish habitat in the River Murray channel. Targeted wetland watering may occur under a range of conditions to support the breeding of colonial nesting waterbirds and other flood-dependent birds.

All potential watering actions are tier 1a under each climatic scenario, except for the spring inundation of floodplain marshes under dry and drought conditions (tier 2). While not a required action for Barmah Forest in 2019–20, other water deliveries in the Murray system may allow the action to be delivered. For example, above-channel-capacity operational transfers from Hume Reservoir may occur through Barmah Forest during spring, meaning a relatively small volume of additional environmental flow could be delivered to achieve the floodplain marsh environmental objectives. A multi-site environmental watering objective supporting whole-of-River-Murray and/or downstream environmental objectives during winter and spring may also deliver flows through Barmah Forest, and these could be supplemented to optimise the site-based outcomes at Barmah Forest. The volume of water for the environment required to achieve the floodplain marsh flow objectives under dry or drought conditions depends on demands for the operational or environmental multi-site events, and it is therefore not estimated in Table 5.2.2 below.

Table 5.2.2 Potential environmental watering for the Barmah Forest under a range of planning scenarios

Planning scenario	Drought	Dry	Average	Wet
Expected river conditions	• Unregulated flow periods unlikely • Flows in the River Murray will remain within channel all year	• Some small unregulated flows in late winter/spring • Low chance of overbank flows in late winter/spring	• Likely chance of small-to-medium unregulated flows in winter/spring • Likely chance of overbank flows in winter/spring	• High probability of moderate-to-large unregulated flows in winter/spring • Expected large overbank flows
Potential environmental watering (tier 1a)	• Winter/spring low flows • Spring/summer freshes (in-channel) • Spring/summer freshes (drought)	• Winter/spring low flows • Spring/summer freshes (in-channel) • Spring/summer/ autumn low flows • Fill Boals Deadwood, Reedy Lagoon and Top Island wetlands	• Winter/spring low flows • Spring/summer freshes (in-channel) • Spring/summer/ autumn low flows • Spring inundation of floodplain marshes • Fill Boals Deadwood, Reedy Lagoon and Top Island wetlands • autumn/winter low flows	• Winter/spring low flows • Spring/summer freshes (in-channel) • Spring inundation of floodplain marshes • Fill Boals Deadwood, Reedy Lagoon and Top Island wetlands • autumn/winter low flows
Potential environmental watering (tier 2)	• Spring inundation of floodplain marshes	• Spring inundation of floodplain marshes		
Possible volume of water for the environment required to achieve objectives[1]	• 3,500 ML (no return flows, tier 1a)	• 51,500 ML (with return flows, tier 1a)	• 566,000 ML (with return flows)	• 570,000 ML (with return flows)

[1] The possible volumes of water for the environment required in Barmah Forest are estimates and highly variable. The actual volume delivered is measured and depends on seasonal conditions. Unregulated and/or operational flows may meet a small to large portion of the demand.

5.2.2 Gunbower Creek and Forest

System overview

Gunbower Forest is a large, flood-dependent forest situated on the River Murray floodplain in northern Victoria between Torrumbarry and Koondrook (Figure 5.2.2).

Covering 19,450 ha, it is bounded by the River Murray to the north and Gunbower Creek to the south. It is an internationally significant site under the Ramsar Convention and forms part of the Living Murray Gunbower-Koondrook-Perricoota forests icon site. River regulation and water extraction from the River Murray and Gunbower Creek has reduced the frequency, duration and magnitude of flood events in Gunbower Forest. This has affected the extent and condition of floodplain habitats and the health of plant and animal communities (such as river red gum and black box communities, native fish, birds, platypus, frogs and turtles) that depend on those habitats.

Gunbower Creek is managed primarily as an irrigation carrier and supplies the Torrumbarry Irrigation Area from the River Murray. Daily variations in water levels in the creek through spring, summer and autumn are much higher now than under natural conditions, due to changing irrigation demand. Frequent or rapid fluctuations in water levels can greatly affect native fish populations and other ecological processes. Water for the environment is used to reduce water level fluctuations by filling the gaps in flows caused by irrigation demand within the creek. This action supports native fish migration and breeding and promotes other ecological processes while maintaining water delivery for irrigation needs.

The Living Murray structural works program in the middle and lower forest was completed in 2013. The works allow up to 4,500 ha of the wetlands and floodplain to be watered with considerably less water than would be required if the new watering infrastructure was not in place. The works enable efficient watering through Gunbower Creek and the forest to maintain wetland and floodplain condition, and they provide a link between the creek, forest floodplain and the River Murray. Frequent connections between the river and floodplain habitats allow biota to move between habitats, and they also support critical ecosystem functions (such as carbon exchange).

Environmental values

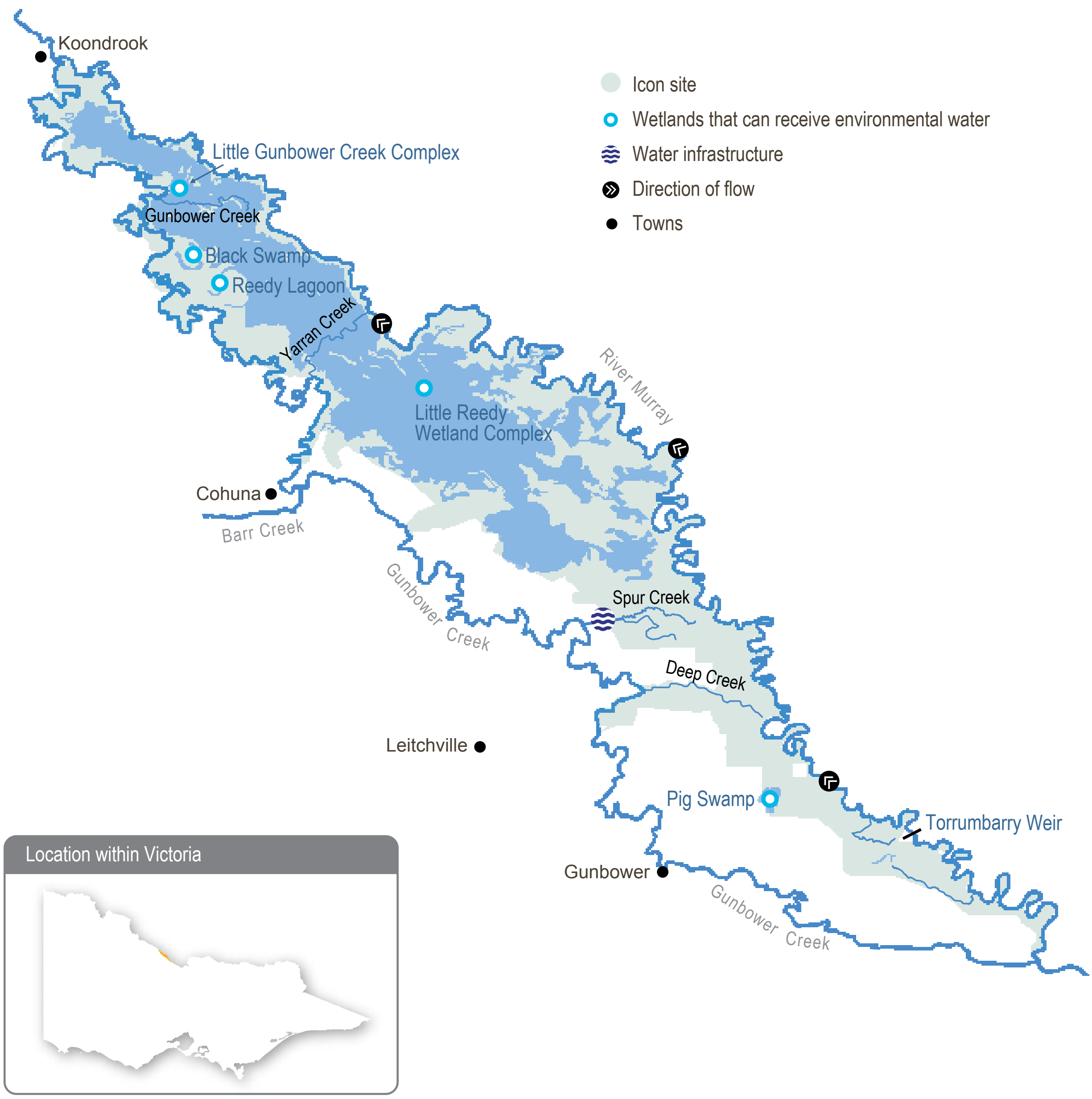
Gunbower Forest contains many important environmental values including rare and diverse wetland habitats, vulnerable and endangered plants (such as river swamp wallaby-grass and wavy marshwort) and animals, and large areas of remnant vegetation communities (such as river red gum forest). The forest provides habitat for many bird and small-bodied native fish species, and it is known to support internationally recognised migratory waterbirds, such as eastern great and intermediate egrets.

Gunbower Creek provides important habitat for native fish (such as Murray cod, golden perch and freshwater catfish). It is a valuable refuge for native fish, and it provides a source of fish to recolonise surrounding waterways.

Environmental objectives in Gunbower Creek and Forest

	Maintain and increase populations of large and small-bodied native fish (such as Murray cod)
	Increase the population of frogs in the forest by providing feeding and breeding habitat
	Maintain connections between the River Murray, Gunbower Forest floodplain, wetlands and floodrunners and Gunbower Creek
	Maintain the population of turtles
	Maintain the health and increase the abundance of native vegetation in priority permanent and semi-permanent wetlands Improve the health of river red gums, black box and grey box communities
	Provide feeding, breeding and refuge habitat for waterbirds including colonial nesting species, such as egrets, cormorants and herons
	Maintain and improve water quality in Gunbower Creek

Figure 5.2.2 Gunbower Creek and Forest



Recent conditions

Following two very hot and dry summers, 51.8 GL of water for the environment was delivered to Gunbower Forest from mid-June 2018 to the end of October 2018. The water inundated about 4,500 ha of the forest floodplain, floodrunners and wetlands, which included 25 percent (3,233 ha) of all river red gum areas and 87 percent (1,199 ha) of all wetlands within Gunbower Forest. The inundation supported the flood-dependent understorey and continued the long-term recovery of wetland plant communities from the Millennium Drought.

Flows into the forest improved the health of river red gum forest habitats. Understorey communities within inundated areas had greater coverage of aquatic, amphibious and mudflat plant species compared to areas that remained dry. Responses in wetlands were more varied, which may be partly due to the presence of large carp. Wetlands with small populations of adult carp (such as Reedy Lagoon) responded well, with dense cover of river swamp wallaby-grass, yellow bladderwort and wavy marshwort appearing during late spring and early summer. Vegetation responses were more limited at Black Swamp, which had a larger carp population.

Managed flows to Gunbower Forest supported many species of waterbirds to breed and successfully fledge their young, including ducks, Australasian grebes and black swans. The resident white-bellied sea eagle pairs at Little Reedy Lagoon and Little Gunbower Lagoon successfully bred in 2018, which is the third year in the row for the pair in Little Reedy Lagoon and the second time in three years for the pair in Little Gunbower. While surveys in September and October 2018 found limited signs of colonial waterbirds nesting, surveys in December 2018 at Long Lagoon found over 50 nests (about 150 juveniles present) including Australasian darter, Australian ibis, little pied cormorants, little black cormorants and great cormorant species. Most chicks fledged successfully by January 2019.

Fish surveys conducted in forest wetlands in autumn 2018 recorded less than half of the native species that would have historically used the wetlands. This result probably reflects recent drying patterns that were implemented since 2016 to remove large-bodied adult carp. Native fish communities are expected to improve in the forest wetlands if future watering events allow connections between the wetlands, Gunbower Creek and the River Murray.

Capacity constraints in Gunbower Creek mean it is not possible to simultaneously deliver large flows to Gunbower Forest and the lower reaches of Gunbower Creek. Environmental flows mainly targeted Gunbower Forest in 2018–19, and therefore flow in the lower reaches of Gunbower Creek was limited to a minimum rate that would still allow native fish to move throughout the system. The lower flow provided an opportunity to test whether native fish (including Murray cod) would spawn without the flow cues that have been provided in Gunbower Creek since 2013–14. Monitoring conducted in spring 2018 detected larvae of Murray cod, carp gudgeon, Australian smelt and flat-headed gudgeon in Gunbower Creek, but breeding rates were considerably lower than previous years. Importantly, most fish larvae were caught below Cohuna Weir, which was the reach that the flows targeted. Monitoring also detected a high abundance of waterbugs, which indicates the system is productive and likely supports the food resources that adult and larval fish need.

In May 2019, water for the environment was delivered to top up Reedy Lagoon in Gunbower Forest, to support the aquatic and amphibious wetland plants and maintain drought refugia for waterbirds, turtles and frogs.

Scope of environmental watering

Table 5.2.3 describes the potential environmental watering actions that may be delivered in 2019–20, their functional watering objectives (that is, the intended physical or biological effect of the watering action) and the longer-term environmental objective they support. Each environmental objective relies on one or more potential environmental watering actions and their associated physical or biological functions.

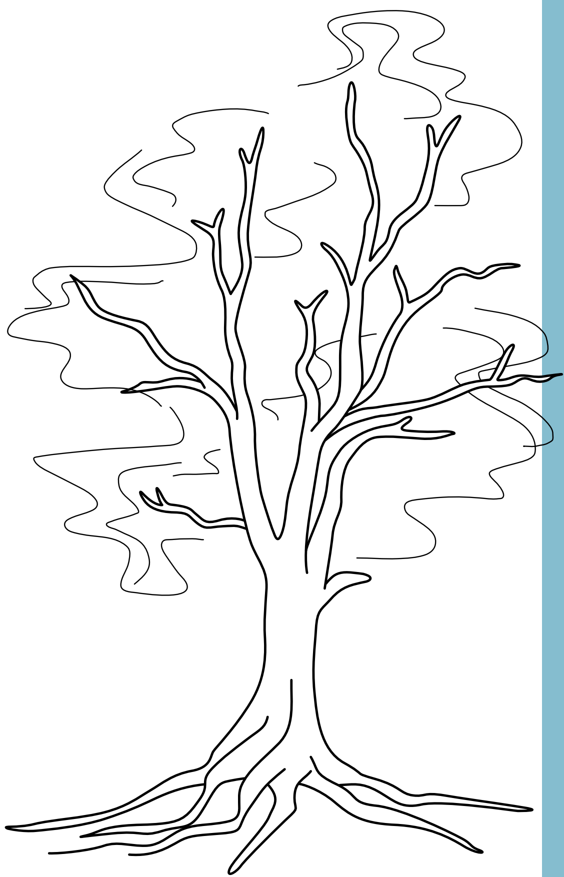


Table 5.2.3 Potential environmental watering actions and objectives for Gunbower Creek and Forest

Potential environmental watering action	Functional watering objective	Environmental objective
Gunbower Forest		
Reedy Lagoon (top-up in winter/spring 2019)	• Maintain the water depth to support wetland plants to flower, set seed and germinate • Maintain the water depth to provide feeding and refuge habitat for waterbirds, turtles and frogs • Maintain the water depth and quality to provide habitat for small-bodied native fish including Murray-Darling rainbowfish	
Little Gunbower wetland complex (fill in winter and provide top-ups if a significant bird-breeding event occurs)	• Maintain the water depth to support wetland plants to flower, set seed and germinate • Provide feeding and refuge habitat for waterbirds and frogs	
Black Swamp (fill in autumn 2020)	• Maintain the water depth to support wetland plants to flower, set seed and germinate • Provide feeding and refuge habitat for waterbirds and frogs	
Green Swamp, Corduroy Swamp and Little Reedy Lagoon (fill in winter 2019)	• Maintain the water depth to support wetland plants to flower, set seed and germinate • Provide feeding and refuge habitat for waterbirds and frogs • Provide habitat for small-bodied native fish	
Winter/spring fresh in Yarran Creek (variable flow rates and duration based on water levels in Gunbower Forest and flows in the River Murray and Gunbower Creek)	• Provide connectivity between Gunbower Creek and the River Murray through the Yarran Creek and Shillinglaws regulators, to increase flowing habitat for the lateral movement of native fish, turtles, carbon, nutrients and seed propagules • Provide migration and spawning opportunities for native fish	
Reedy Lagoon (top-up in autumn/winter 2020)	• Maintain the water depth to support wetland plants to flower, set seed and germinate • Maintain feeding and refuge habitat for waterbirds and frogs • Maintain habitat for small-bodied native fish including Murray-Darling rainbowfish	
Extend natural flooding in the Gunbower Forest floodplain, floodrunners and wetlands (with variable flow rates to maintain appropriate inundation extent)	• Inundate river red gum, black box and grey box communities • Provide access to breeding habitat and food resources for native fish (such as Murray cod) • Provide refuge habitat for waterbirds including colonial nesting species	

Table 5.2.3 Potential environmental watering actions and objectives for Gunbower Creek and Forest *continued...*

Potential environmental watering action	Functional watering objective	Environmental objective
Gunbower Creek		
Winter low flows (above 300 ML/day during May to August)	• Provide access to habitat and food resources for native fish (such as Murray cod)	
Spring/summer/autumn high flows (targeting a gradual increase, stable flow period and decrease in flows ranging between 300–600 ML/day during August to May)	• Provide access to breeding habitat and food resources for native fish (such as Murray cod) • Provide cues for the migration and spawning of native fish	
Year-round low flows (above 300 ML/day)[1]	• Increase access to habitat and food resources for native fish	
Increased low flows (up to 550 ML/day year-round if unregulated conditions occur in the River Murray)[2]	• Increase recruitment from the River Murray populations into the creek by providing enough flow for native fish to migrate and spawn • Provide access to breeding habitat and food resources for native fish (such as Murray cod)	
Spring/summer/autumn freshes (up to 550 ML/day for two to four weeks during October to April)[2]	• Increase recruitment from the River Murray populations into the creek by providing cues for native fish to migrate and spawn • Dilute low-dissolved-oxygen water exiting Gunbower Forest below Koondrook Weir	

1 Year-round low flows may be provided when delivery to Gunbower Forest through the Hipwell Road Channel regulator is occurring, to optimise the volume that can be delivered to the floodplain.

2 Increased low flows and freshes may be provided opportunistically in Gunbower Creek if unregulated conditions eventuate in the River Murray and the Hipwell Road Channel regulator is not being used.

Scenario planning

Table 5.2.4 outlines the potential environmental watering and expected water use under a range of planning scenarios.

The key objectives in 2019–20 are to build on the significant, positive ecological outcomes that were observed after floodplain watering in 2018–19 and provide refugia for wetland-dependent plants and animals. Unless naturally triggered, it is unlikely that large-scale floodplain watering will be delivered in winter/spring, and the focus of the delivery of water for the environment will be consolidating the outcomes of past watering actions in some wetlands in the forest.

In drought, dry and average conditions, the environmental watering priorities will be to maintain and improve the condition of semi-permanent and permanent wetlands across the forest and support local populations of waterbirds and small-bodied native fish. Delivering water to some permanent and semi-permanent wetlands in winter and spring 2019 will provide habitat for waterbirds and other wetland-dependent animals during the cooler months and prime the wetlands for a spring productivity boost. Topping up wetlands in autumn will help to maintain wetland vegetation and provide refuge over winter for water-dependent animals including waterbirds, if dry conditions persist into the first half of 2020 and beyond.

Under average or wet conditions, unregulated flows from the River Murray may inundate parts of the Gunbower Forest floodplain. Under these circumstances, water for the environment may be used to extend a flooding event in selected river red gum areas, to maintain and improve tree health.

If flow in the River Murray exceeds 15,000 ML per day for more than two weeks in winter/spring, a fresh may be delivered in Yarran Creek to allow carbon, fish, turtles and seed propagules to move between Gunbower Creek, Gunbower Forest and the River Murray. This event may be provided in dry to wet scenarios but is a lower priority under drought conditions.

Under all climatic conditions, water for the environment may be used to support a natural waterbird breeding event. This action would be based on the size of the breeding event and likelihood that chicks will fledge without additional water.

Gunbower Creek is a highly regulated system. As a result, natural conditions (such as flooding and rainfall) do not greatly influence the objectives or flow requirements in the system. Management of water for the environment will aim to support all aspects of native fish life cycles, ensuring there are sufficient habitat and food resources for native fish throughout the year.

The highest priority for water for the environment for Gunbower Creek is to maintain flowing habitat and access to feeding resources for native fish during winter, when historically, outside of the irrigation season, the creek was drawn down to pools. The second-highest priority is to smooth out flows during the irrigation season to provide opportunities for native fish (especially Murray cod) to breed and for their larvae to disperse.

In a wet climate scenario, water for the environment may be used to provide short freshes or increased low flows in Gunbower Creek. These flows may facilitate native fish movement between Gunbower Creek and the River Murray and cue spawning at a time when fish populations are likely to be responding to larger flows in the River Murray and other connected tributaries.

If water for the environment is used in 2019–20 to extend the duration or extent of a natural flood in Gunbower Forest, it may not be possible to deliver the full range of flows for large-bodied fish in Gunbower Creek. Under these circumstances, flow in Gunbower Creek will be managed to maintain habitat for the existing native fish population. A fresh may be delivered downstream of Koondrook Weir to dilute low-oxygen floodwater that drains from the floodplain into the river.

A minimum volume of 13,900 ML is planned to be carried over into 2020–21 to provide certainty of supply for low flows in Gunbower Creek during the winter period outside the irrigation season (between 15 May and 15 August each year), to maintain flowing habitat. Additionally, carryover volumes will support the winter/spring 2020 fills and top-ups of permanent wetlands in lower Gunbower Forest, to ensure habitat is available for small-bodied native fish, waterbirds and other aquatic plant and animal species.

Table 5.2.4 Potential environmental watering for Gunbower Creek and Forest under a range of planning scenarios

Planning scenario	Drought	Dry	Average	Wet
Expected river conditions	• No natural inflows into Gunbower Forest	• Minor natural inflows into Gunbower Forest may occur in winter/spring	• Some natural inflows into Gunbower Forest are likely in winter/spring but unlikely to be significant	• Overbank flows are likely in winter/spring
Potential environmental watering – tier 1 (high priorities)[1]	• Reedy Lagoon (winter/spring) • Little Gunbower wetland complex • Black Swamp • Gunbower Creek winter low flows • Gunbower Creek spring/summer/autumn high flows	• Reedy Lagoon (winter/spring) • Little Gunbower wetland complex • Green Swamp, Corduroy Swamp and Little Reedy Lagoon • Black Swamp • Gunbower Creek winter low flows • Gunbower Creek spring/summer/autumn high flows	• Reedy Lagoon (winter/spring) • Little Gunbower wetland complex • Green Swamp, Corduroy Swamp and Little Reedy Lagoon • Extend natural flooding by inundation of Gunbower Forest floodplain, floodrunners and wetlands (winter/spring) • Yarran Creek winter/spring fresh • Black Swamp • Gunbower Creek winter low flows[2] • Gunbower Creek spring/summer/autumn high flows[2]	• Reedy Lagoon (winter/spring) • Little Gunbower wetland complex • Green Swamp, Corduroy Swamp and Little Reedy Lagoon • Extend natural flooding by inundation of Gunbower Forest floodplain, floodrunners and wetlands (winter/spring) • Yarran Creek winter/spring fresh • Black Swamp • Gunbower Creek winter low flows[2] • Gunbower Creek spring/summer/autumn high flows[2]

Table 5.2.4 Potential environmental watering for Gunbower Creek and Forest under a range of planning scenarios *continued...*

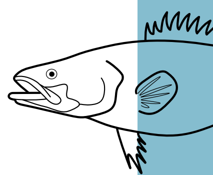
Planning scenario	Drought	Dry	Average	Wet
Potential environmental watering – tier 2 (additional priorities)	• Green Swamp, Corduroy Swamp and Little Reedy Lagoon • Reedy Lagoon (autumn/winter)	• Reedy Lagoon (autumn/winter) • Yarran Creek winter/spring fresh • Inundation of Gunbower Forest floodplain, floodrunners and wetlands (autumn/winter)	• Reedy Lagoon (autumn/winter) • Inundation of Gunbower Forest floodplain, floodrunners and wetlands (autumn/winter)	• Reedy Lagoon (autumn/winter) • Inundation of Gunbower Forest floodplain, floodrunners and wetlands (autumn/winter) • Gunbower Creek autumn/winter/spring increased low flows • Gunbower Creek spring/summer/autumn freshes
Possible volume of water for the environment required to meet objectives [3,4]	• 27,100 ML (tier 1) • 7,500 ML (tier 2)	• 35,000 ML (tier 1) • 29,000 ML (tier 2)	• 46,000 ML (tier 1) • 28,500 ML (tier 2)	• 46,000 ML (tier 1) • 34,500 ML (tier 2)
Priority carryover requirements	• 13,900 ML	• 13,900 ML	• 13,900 ML	• 13,900 ML

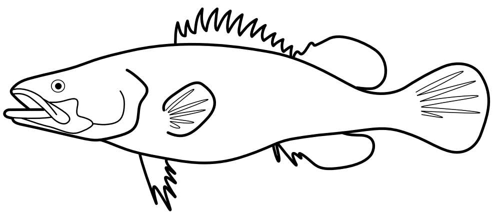
1 *Under tier 1 actions in all planning scenarios, an additional 900 ML (drought) and 1,500 ML (dry to wet) has been included to support a significant bird-breeding event that may be triggered by Gunbower floodplain inundation or wetland watering.*

2 *When the Hipwell Road Channel regulator is in operation, the highest-priority watering action will be to maintain a minimum year-round low flow of 300 ML per day, which will replace Gunbower Creek winter low flows and Gunbower Creek spring/summer/autumn high flows watering actions where this is the case.*

3 *Water for the environment requirements for tier 2 actions are additional to tier 1 requirements.*

4 *These estimates take account of the use of operational water en route to achieve watering action targets (except for discrete wetland watering actions), with water for the environment being required to underwrite the associated losses in Gunbower Creek and Gunbower Forest.*





5.2.3 Central Murray wetlands

System overview

The central Murray wetlands are located on the lower Loddon River and River Murray floodplains. The wetland system includes Round Lake, Lake Cullen, Lake Elizabeth, Lake Murphy, Johnson Swamp, Hird Swamp, Richardsons Lagoon, McDonalds Swamp, the Wirra-Lo wetland complex and Benwell and Guttrum state forests.

The central Murray wetlands are almost wholly contained within the Torrumbarry Irrigation Area and are all wetlands of regional or international significance. The area has experienced dramatic changes since European settlement with the construction of levees, roads and channels. Most of the wetlands are now cut off from natural flow paths and are rarely inundated by natural floods. They rely on water for the environment to maintain their ecological character and health.

Nine of the central Murray wetlands can receive water for the environment from permanent infrastructure: Lake Cullen, Hird Swamp, Johnson Swamp, Round Lake, McDonalds Swamp, Lake Elizabeth, Lake Murphy, Richardsons Lagoon and the Wirra-Lo wetland complex. Temporary pumps may be used to deliver water for the environment from the River Murray to some semi-permanent wetlands in the Guttrum and Benwell forests.

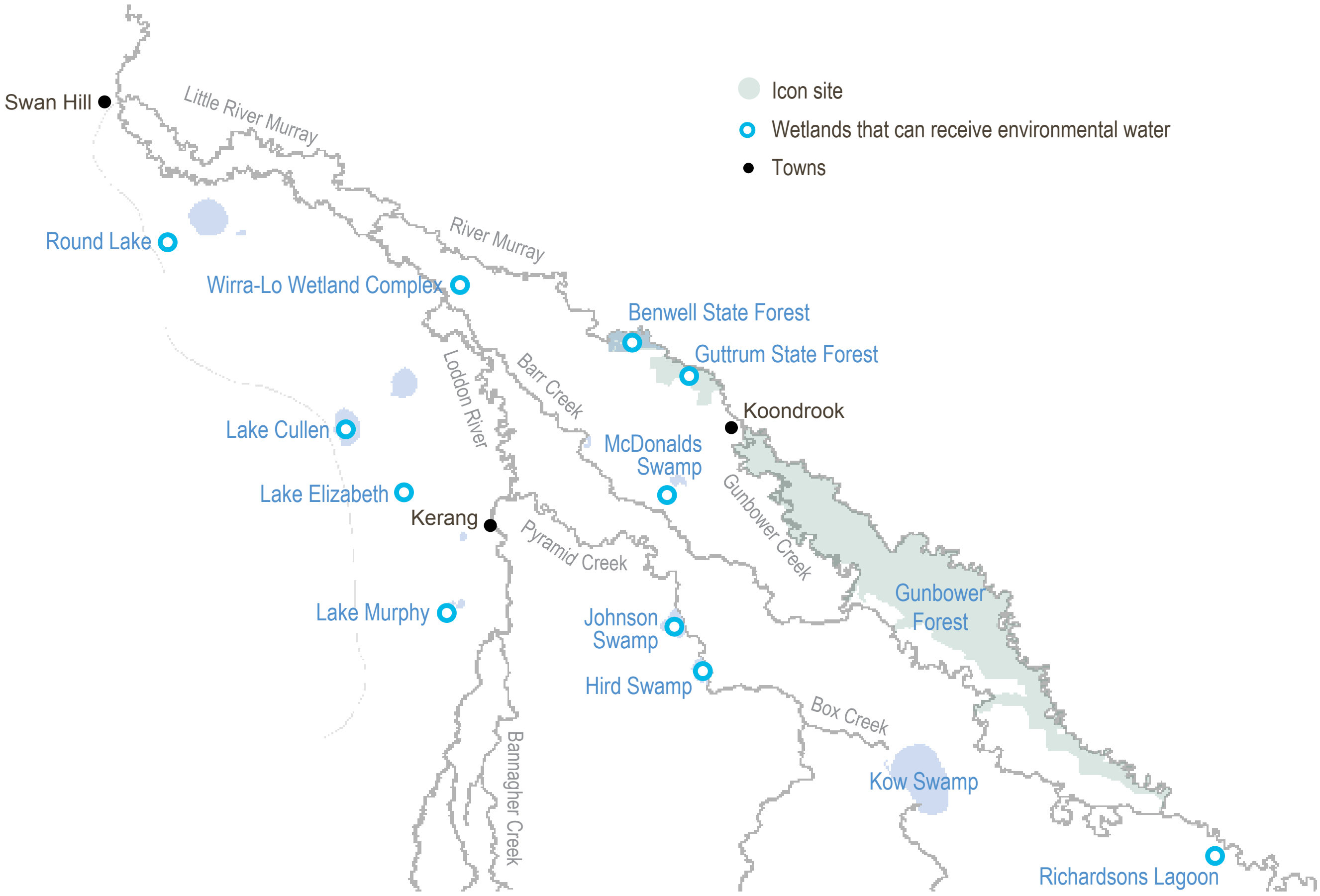
Environmental values

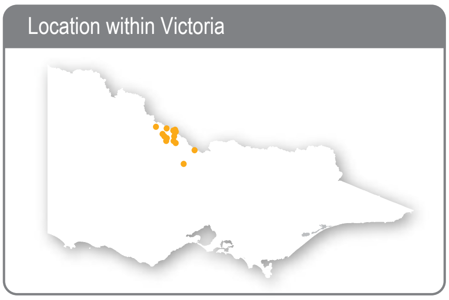
The wetlands in the central Murray system support vulnerable or endangered species including the Australasian bittern, Murray hardyhead, Australian painted snipe and growling grass frog. The wetlands provide habitat for many threatened and endangered bird species (including the eastern great egret and white-bellied sea eagle) listed under legislation and international agreements. Lake Cullen, Hird Swamp and Johnson Swamp are internationally recognised under the Ramsar Convention, while the other wetlands in the central Murray system have bioregional significance.

Environmental objectives in the central Murray wetlands

	Restore the population of critically endangered Murray hardyhead Maintain or increase the population of common, small-bodied native fish (such as carp gudgeon and flat-headed gudgeon)
	Restore populations of endangered growling grass frog Maintain the populations of common native frogs (such as barking marsh frog, Peron's tree frog and spotted grass frog)
	Supply carbon to Pyramid Creek to boost the riverine foodweb
	Maintain the population of native turtle species (such as the Murray River turtle and the common long-necked turtle)
	Restore and maintain the health of riparian trees (such as river red gum and black box) Restore and maintain mudflat vegetation communities (such as tall marsh, herblands, rushes and sedges) Restore and maintain native aquatic vegetation species (such as tassel, milfoil and pondweed) Reduce the extent and density of invasive plant species Support a mosaic of wetland plant communities across the region
	Provide habitat for waterbird nesting, feeding and breeding for a variety of feeding guilds, including threatened species (such as Australasian bittern, little bittern and brolga)
Aboriginal environmental outcomes	
	Watering is planned to be delivered in partnership with Traditional Owners and achieve Aboriginal environmental outcomes

Figure 5.2.3 The central Murray wetlands





Recent conditions

Northern Victoria experienced drier and warmer conditions than average across 2018–19, with inflows to major storages tracking between dry to below average. Water for the environment was delivered to seven of the central Murray wetlands in 2018–19, as planned under a dry climate scenario.

In Round Lake and Lake Elizabeth, water for the environment was periodically used to maintain salinity within the target range for endangered Murray hardyhead, which were stocked in 2018 and 2016. Sampling at Lake Elizabeth in autumn 2018 found 24 Murray hardyhead (indicating successful recruitment, as the fish live for less than two years) and an additional 300 Murray hardyhead were released in Round Lake in October 2018 as part of a statewide translocation project.

Lake Cullen received water for the environment in spring 2018, which is the first time it has been watered independently of the Avoca Marshes. Until recently, it was thought that groundwater interactions forced saline water into the marshes when Lake Cullen was full. Recent investigations confirmed that this is not the case, which means water for the environment can be used as needed (irrespective of water levels in the Avoca Marshes) to support more environmental objectives in the lake. A waterbird survey conducted at Lake Cullen after the spring 2018 watering event recorded over 29,000 individual waterbirds, representing 60 waterbird species. Further monitoring was undertaken by Barapa Barapa and Wamba Wemba Traditional Owners in winter 2019.

Lignum Swamp North and Brolga Swamp, within the Wirra-Lo wetland complex, received water for the environment in 2018–19. Six frog species including the endangered growling grass frog were recorded at the wetland throughout spring/summer.

Water for the environment was also delivered to McDonalds Swamp, Lake Murphy and Johnson Swamp in 2018–19, to promote vegetation growth to support feeding and breeding for birds.

Scope of environmental watering

Table 5.2.5 describes the potential environmental watering actions that may be delivered in 2019–20, their functional watering objectives (that is, the intended physical or biological effect of the watering action) and the longer-term environmental objective they support. Each environmental objective relies on one or more potential environmental watering actions and their associated physical or biological functions.

Two new wetlands within the Wirra-Lo wetland complex have been added to the environmental watering program in 2019–20. These wetlands have been created as part of the national Bringing Back the Bitterns project, which aims to restore local populations of the endangered Australasian bittern. These wetlands are not yet named, and they are referred to as Bittern East and Bittern West in this plan.

Table 5.2.5 Potential environmental watering actions and objectives for the central Murray wetlands

Potential environmental watering action	Functional watering objective	Environmental objective
Round Lake (top-ups as required to maintain water quality targets)	• Maintain salinity within 25,000–40,000 EC[1] to support suitable habitat and breeding conditions for Murray hardyhead and growing conditions for submerged aquatic plants	
Lake Elizabeth (top-ups as required to maintain water quality targets)	• Maintain salinity within 25,000–40,000 EC[1] to support suitable habitat and breeding conditions for Murray hardyhead and growing conditions for submerged aquatic plants • Provide permanent water as habitat for waterbirds	
Wirra-Lo wetland complex – Duck Creek North, Duck Creek South, Lignum Swamp North and Brolga Swamp (fill in spring)	• Maintain the health of open woodland vegetation, lignum and other aquatic vegetation • Provide feeding and breeding habitat for growling grass frog and other frog species • Provide foraging habitat for shallow-wading waterbirds and mudflat specialists • Provide refuge and recruitment sites for freshwater turtles	
Wirra-Lo wetland complex – Red Gum Swamp (fill in spring)	• Maintain the health of existing red gum trees	
Wirra-Lo wetland complex – Bittern West and Bittern East wetlands (partial fill in spring)	• Support the growth of newly-established reed beds to create nesting habitat for Australasian bittern	

Table 5.2.5 Potential environmental watering actions and objectives for the central Murray wetlands *continued...*

Potential environmental watering action	Functional watering objective	Environmental objective
Guttrum Forest (fill in spring and autumn, with top-ups in summer if required to support waterbird breeding)	• Inundate the existing adult river red gums to support their growth and drown river red gum saplings in the open-water habitat • Promote the growth and re-establishment of aquatic and tall marsh vegetation • Maintain the depth of the wetland to support waterbird feeding and breeding	
Johnson Swamp (fill in spring – with through-flow to Pyramid Creek, with top-ups in summer/autumn to support bird breeding if required[2])	• Promote waterbird breeding and feeding • Restrict the growth of tall marsh vegetation by preventing otherwise favourable warm, shallow-water conditions • Promote the growth of aquatic herbland species • Provide refuge and recruitment sites for freshwater turtles • Provide carbon and nutrients to Pyramid Creek	
McDonalds Swamp (partial fill in autumn)	• Promote the growth of planted and naturally recruited river red gums • Support the germination of aquatic vegetation • Promote winter feeding conditions for waterbirds and frogs	
Lake Cullen (top-up in spring, and as required to support waterbird breeding[2])	• Maintain waterbird refuge • Promote the growth and recruitment of submerged aquatic plants • Maintain water levels to support waterbird breeding	
Wetland drying		
Lake Murphy, Hird Swamp and Richardsons Lagoon will not be actively watered in 2019–20	• Prevent drowning existing trees in the bed of wetlands • Promote herbland species and establish fringing vegetation around the edge of each wetland • Reduce the extent of water-dependent invasive species (such as cumbungi) • Allow for oxidation of the soil (Richardsons Lagoon)	

1 EC stands for electrical conductivity, which is a measure of water salinity.

2 Top-ups to support waterbird breeding may occur if species of high conservation significance display breeding behaviour or nesting activity, or if large numbers of waterbirds have nests with live chicks.

Scenario planning

Table 5.2.6 outlines the potential environmental watering and expected water use under a range of planning scenarios.

North Central CMA has undertaken landscape-scale planning for these wetlands to optimise the wetland watering regimes over multiple years. An important consideration in this planning is to ensure there is a large variety of habitat types available across the region to support waterbirds and other water-dependent animals at any time.

The highest environmental watering priorities under all planning scenarios are to water wetlands that protect the critically endangered Murray hardyhead, and provide habitat for nationally threatened species (such as the growling grass frog): that is, Round Lake, Lake Elizabeth and Wirra-Lo wetland complex. Watering Johnson Swamp is also a high priority under all climate scenarios, as it provides quality breeding and feeding habitat for a range of waterbird species across the landscape, and other nearby wetlands that rely on managed water deliveries are likely to experience drying phases. It is important to maintain some breeding and feeding habitat for waterbirds, irrespective of the climate scenario.

Watering Guttrum Forest in spring is a high priority under drought, dry and average planning scenarios, to rehabilitate and assist the recovery of the wetland vegetation community through a more-frequent flooding regime. Water may also be delivered to Guttrum Forest under any scenario, if there is a natural waterbird breeding event. Under wet conditions, natural inflows from the River Murray will likely inundate Guttrum Forest. If sufficient water is available in autumn/winter 2020, it may be prudent to re-fill Guttrum Forest to prime the wetland vegetation for the following spring, boost productivity and drown terrestrial vegetation in low-lying parts of the wetland to maintain important open-water habitat.

If sufficient water is available, water for the environment will be allowed to flow through Johnson Swamp to Pyramid Creek to boost the carbon supply to Pyramid Creek and increase the productivity of the riverine foodweb. The timing of the flow would coincide with a spring fresh in Pyramid Creek. This is a good example of how water for the environment can be used to support fundamental ecological processes and optimise ecological outcomes across multiple waterways. The potential watering actions for Pyramid Creek are detailed in section 5.7.1. A fresh may be delivered irrespective of a flow from the swamp: hence, providing a flow through Johnson Swamp is a secondary priority.

Lake Cullen provides important refuge during drought or dry condition for waterbirds, particularly species with restricted or small ranges. Lake Cullen may be watered in 2019–20 if there is limited waterbird habitat across the landscape (that is, in drought or dry conditions), but prolonged inundation may damage mudflat vegetation. The North Central CMA will evaluate these competing objectives before requesting water to fill Lake Cullen in 2019–20. Watering of Lake Cullen is therefore a secondary priority in wetter climate scenarios.

If sufficient water is available, McDonalds Swamp will receive a partial fill in autumn to promote growth of planted and naturally recruited river red gums, support plant germination and promote winter feeding conditions for waterbirds and frogs and prime the wetland to respond as weather warms up in spring 2020. Priming the wetland in this way will promote a greater environmental response to watering scheduled for 2020–21, however it is not critical to achieving outcomes in 2020–21, and therefore is a secondary priority for 2019–20.

There are no plans to deliver water for the environment to Lake Murphy, Hird Swamp and Richardsons Lagoon in 2019–20. These wetlands are due to experience a drying phase to promote the growth of herbland species and fringing vegetation, to control the extent of water-dependent invasive vegetation species, to allow existing trees in the bed of the wetland to breathe and to allow oxidation of the soil.

Priority carryover requirements have been calculated based on the required volume to support Murray hardhead sites in 2020–21.

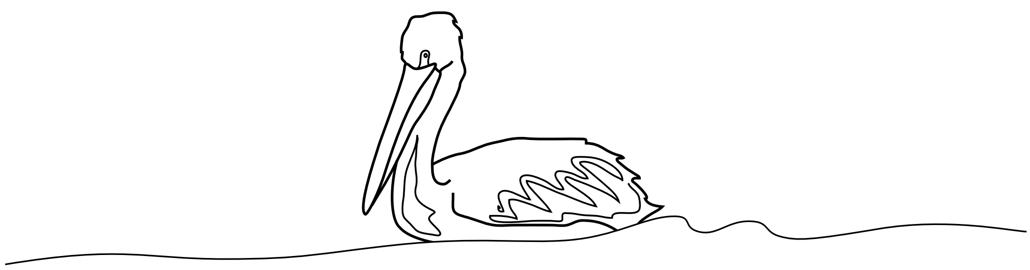


Table 5.2.6 Potential environmental watering for the central Murray wetlands under a range of planning scenarios

Planning scenario	Drought	Dry	Average	Wet
Expected catchment conditions	• Catchment run off and unregulated flows into the wetland are unlikely	• Some catchment run off and unregulated flows into the wetlands are possible, particularly in winter/spring	• Low-to-moderate catchment run off and unregulated flows into the wetlands are likely, particularly in winter/spring	• Catchment run off and unregulated flows into the wetlands may significantly contribute to water levels in some wetlands, particularly winter/ spring
Potential environmental watering – tier 1 (high priorities)[1]	• Round Lake • Lake Elizabeth • Wirra-Lo wetland complex (Brolga Swamp, Red Gum Swamp, Bittern West and Bittern East) • Guttrum Forest (winter/spring) • Johnson Swamp • Lake Cullen	• Round Lake • Lake Elizabeth • Wirra-Lo wetland complex (Brolga Swamp, Red Gum Swamp, Bittern West and Bittern East) • Guttrum Forest (winter/spring) • Johnson Swamp • Lake Cullen	• Round Lake • Lake Elizabeth • Wirra-Lo wetland complex (Brolga Swamp, Red Gum Swamp, Bittern West and Bittern East) • Guttrum Forest (winter/spring) • Johnson Swamp • Johnson Swamp 'through flow'	• Round Lake • Lake Elizabeth • Wirra-Lo wetland complex (Brolga Swamp, Red Gum Swamp, Bittern West and Bittern East) • Guttrum Forest • Johnson Swamp • Johnson Swamp 'through flow'
Potential environmental watering – tier 2 (additional priorities)	• McDonalds swamp • Johnson Swamp 'through flow'	• McDonalds swamp • Johnson Swamp 'through flow' • Guttrum Forest (autumn/winter)	• Lake Cullen • Guttrum Forest (autumn/winter)	• Lake Cullen
Possible volume of water for the environment required to achieve objectives[2]	• 14,800 ML (tier 1) • 600 ML (tier 2)	• 14,800 ML (tier 1) • 1,000 ML (tier 2)	• 7,400 ML (tier 1) • 400 ML (tier 2)	• 7,400 ML (tier 1) • 0 ML (tier 2)
Priority carryover requirements	• 2,300–2,400 ML			

1 *It is not possible to distinguish between tier 1a and 1b demands for the Central Murray wetlands as there is no individual entitlement (and therefore no expected supply volume) for them. Rather the water is shared and prioritised across several systems. Wetlands are listed in priority order for tier 1 and tier 2 under all climate scenarios.*

2 *Water for the environment requirements for tier 2 actions are additional to tier 1 requirements.*

5.2.4 Hattah Lakes

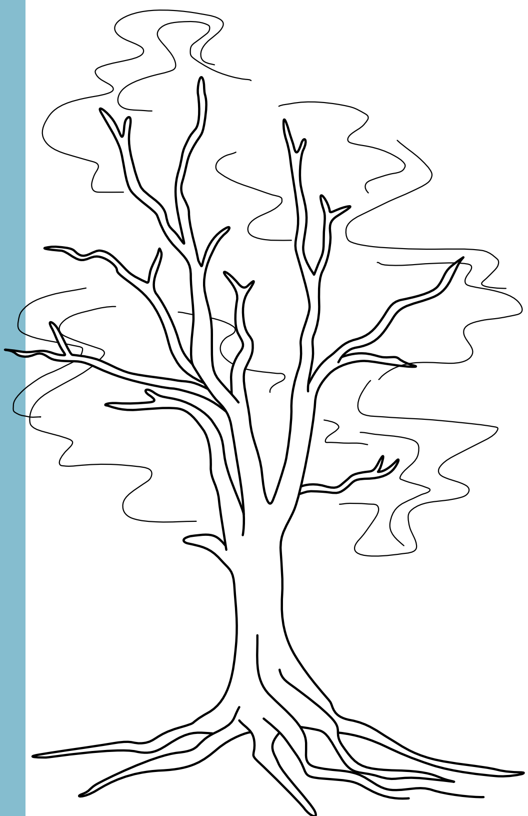
System overview

Hattah-Kulkyne National Park is situated in north-west Victoria adjacent to the River Murray, as Figure 5.2.4 shows. The national park contains a complex of more than 20 semi-permanent freshwater lakes known collectively as the Hattah Lakes.

The ecology of the Hattah Lakes and surrounding floodplain is strongly influenced by flooding regimes of the River Murray. The system fills when there are high flows in the River Murray, and some lakes hold water for numerous years after floods recede. Regulation of the River Murray has significantly reduced the frequency and duration of small- to medium-sized natural floods in the Hattah Lakes system. Over time, this has degraded vegetation communities and reduced the diversity and abundance of animals that use the vegetation and wetlands for habitat and food.

The Hattah Lakes complex can be broadly divided into the southern Hattah Lakes, which contain permanent to semi-permanent wetlands, and the higher-elevation northern Hattah Lakes, which are mostly ephemeral wetlands.

The Messenger, Oateys and Cantala regulators allow water to flow between the River Murray and the Hattah Lakes. When flows in the River Murray are about 26,000 ML per day, water begins to flow through the Messenger regulator into Chalka Creek and through to the Hattah Lakes complex. A permanent pump station has also been constructed that can deliver up to 1,000 ML per day to Hattah Lakes through Chalka Creek. The regulators and pump station are used in combination with several small constructed levees to restore a beneficial pattern of flooding to the lakes.



Lake Kramen in the south-east of Hattah-Kulkyne National Park is disconnected from the main Hattah Lakes complex. The Hattah Lakes pump station can deliver up to 145 ML per day to Lake Kramen to restore flooding regimes.

Environmental values

Hattah Lakes is home to a diverse range of flood-dependent vegetation that changes with the topography of the landscape. Vegetation types range from wetland communities in lower-lying areas that require almost annual flooding to lignum and black box communities situated higher on the floodplain that only need flooding once every four to five years on average.

A combination of natural flooding and the delivery of environmental flows since 2010 has improved tree canopy health and recruitment of black box and river red gum communities throughout the Hattah Lakes. Woodland birds (including the endangered regent parrot) have benefitted from the improved tree health.

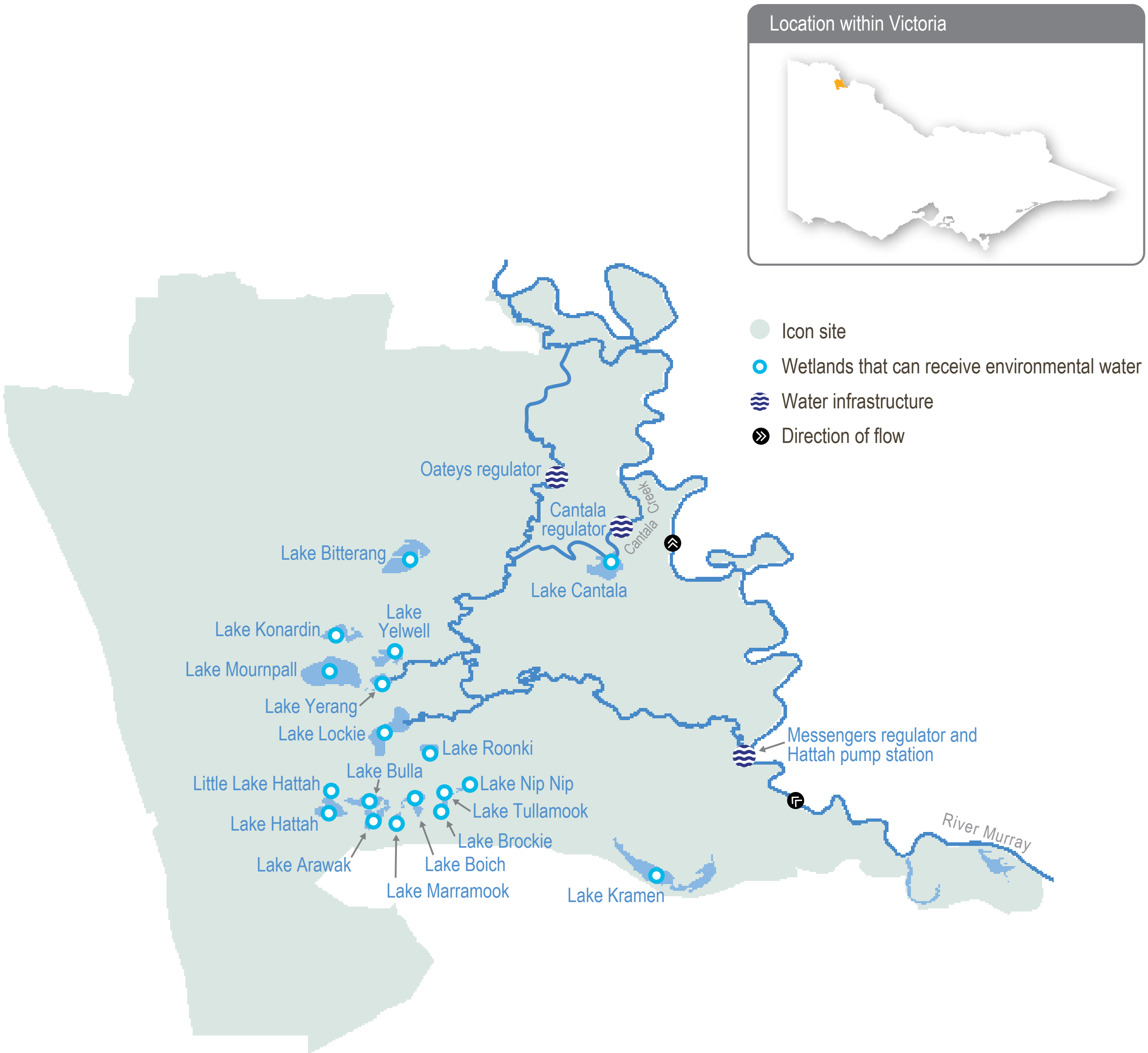
Hattah Lakes provides important waterbird breeding sites in an arid landscape. A total of 34 species of waterbirds are known to breed at the lakes when conditions are suitable. Another six species of waterbirds breed in the surrounding floodplain. Wetland drought-refuge sites are limited in the region, making Hattah Lakes critically important for waterbirds and terrestrial animals.

The Hattah Lakes support native fish species (such as golden perch and endangered freshwater catfish), which can move between the lakes and the River Murray when flows are suitable. Fish can also persist in permanent wetlands in the Hattah Lakes during dry years.

Environmental objectives in the Hattah Lakes

	Increase the fish population by supporting breeding
	Restore and maintain a mosaic of healthy wetland and floodplain plant communities
	Provide feeding and nesting habitat for the successful recruitment of waterbirds and woodland birds

Figure 5.2.4 The Hattah Lakes system



Recent conditions

Hattah Lakes last received natural inflows from the River Murray during spring 2016. Over 110 GL of water for the environment was delivered to Hattah Lakes between July and October 2017 via the Hattah pumps station, to build on environmental outcomes from the 2016 floods. Almost half the water pumped to the lakes flowed back into the River Murray, providing environmental benefits to high-priority environmental watering sites downstream.

Environmental flows in 2017 provided the most-extensive floodplain inundation at Hattah Lakes since the 1990s and supported the germination, growth and recovery of black box trees. Over several years, there has also been an increase in wetland plant diversity, demonstrated recruitment of small-bodied fish and an increased abundance of woodland birds.

The 2017–18 and 2018–19 summers were exceptionally hot and dry, and lakes within the Hattah complex completely dried, except Hattah Lake and Mournpall Lake. This drying pattern is important and has allowed floodplain and wetland plant communities to germinate, grow and reproduce a seedbank in preparation for the next flood.

Lake Kramen was last filled in 2014–15. It did not receive any inflow during the 2016 floods, and it has been completely dry since 2017. The dry phase allowed the growth of lake bed vegetation, which will provide an important source of carbon to support productive foodwebs when the wetland is next filled.

Scope of environmental watering

Table 5.2.7 describes the potential environmental watering actions that may be delivered in 2019–20, their functional watering objectives (that is, the intended physical or biological effect of the watering action) and the longer-term environmental objective they support. Each environmental objective relies on one or more potential environmental watering actions and their associated physical or biological functions.

Table 5.2.7 Potential environmental watering actions and objectives for the Hattah Lakes

Potential environmental watering action[1]	Functional watering objective	Environmental objective
Lake Kramen (fill to 46.0 m AHD in winter/spring)	• Inundate fringing river red gums and black box trees to stimulate their growth and improve their condition • Provide refuge and feeding habitat for waterbirds • Provide conditions for lake bed herbaceous plants to grow in the drawdown phase after watering	
Southern Hattah Lakes[2] (partial fill to 42.5 m AHD in autumn/winter)	• Stimulate growth to improve the condition of river red gums • Provide refuge and feeding habitat for waterbirds • Stimulate the growth of aquatic vegetation in wetlands that are currently dry	
Hattah Lakes (floodplain inundation up to 45.0 m AHD at any time if there is a natural flood)	• Inundate river red gums and black box on the floodplain to stimulate the growth and improve the condition of mature trees • Provide suitable soil conditions for the germination of black box trees on the floodplain and support the growth of trees that germinated in the flows provided in 2017 • Provide suitable conditions to support waterbird and woodland bird breeding and feeding • Provide connections to allow native fish to move between Hattah Lakes and the River Murray • Provide spawning and recruitment habitat for small-bodied native fish and nursery habitat for large-bodied natives (such as golden perch)	

1 The Hattah Lakes pumps station may also be operated at any time of year to meet maintenance requirements.

2 Includes the following lakes: Bulla, Hattah, Little Hattah, Lockie, Yelwell and Yerang.

Scenario planning

Table 5.2.8 outlines the potential environmental watering and expected water use under a range of planning scenarios.

There are three watering actions planned for the Hattah Lakes in 2019–20: pumping water to Lake Kramen in spring; pumping water to provide a partial fill of the southern Hattah Lakes in autumn; and widespread floodplain inundation that may be achieved under a wet scenario from a combination of natural flows and managed environmental flows.

Lake Kramen has been dry for three years, and the river red gums and fringing black box vegetation are showing signs of water stress. It is proposed to fill Lake Kramen in winter/spring under dry and average scenarios to help the trees grow and recover. Under a drought scenario, Lake Kramen may be filled if the monitoring of tree condition indicates that water is needed[8]; otherwise it will be allowed to dry for another year. Under a wet scenario, widespread natural flooding may remove the need for environmental watering at Lake Kramen, but if floods do not reach the target inundation extent, supplementary pumping may be needed to meet the site objectives.

Unless there is a natural flood, Lake Hattah will likely dry by autumn 2020, leaving Lake Mournpall as the only water in the southern lakes system and therefore the only remaining refuge for carp. Environmental flows are normally delivered to Hattah Lakes during spring. However, under dry and average climate scenarios, the intention is to water the southern lakes in autumn (outside of peak carp reproduction time) to minimise the numbers of juvenile and larval carp that can enter the system through the pumps that draw water from the River Murray. The watering will not connect Lake Mournpall to the other lakes, so the remaining adult carp in Lake Mournpall will not be able to populate the newly-filled wetlands. Although the timing of the planned partial fill is not optimal for the spring regrowth of vegetation in 2019, water will remain in the lakes to support regrowth in the following spring/summer, when there is less aquatic plant damage as a result of fewer carp.

Under a drought scenario, the southern Hattah Lakes will be allowed to completely dry, unless routine tree condition monitoring indicates that river red gums fringing wetlands are severely stressed and are likely to die. Under a wet scenario, the lakes will be naturally inundated and therefore water for the environment may not be needed to achieve the planned partial fill. Water for the environment may be used to extend the magnitude and duration of a small-sized natural flood to support river red gum and black box trees on the floodplain. However, this objective is a low priority (tier 2) for 2019–20 because some areas of the floodplain at lower elevations will benefit from a drying phase that will help to maintain the diversity of wetland plant communities.

Table 5.2.8 Potential environmental watering for the Hattah Lakes under a range of planning scenarios

Planning scenario	Drought	Dry	Average	Wet
Expected river conditions	• Low flows year-round in the River Murray and no natural inflows to Hattah Lakes; substantial wetland drying will occur	• Rare high-flow events in the River Murray and no natural inflows to Hattah Lakes; substantial wetland drying will occur	• Short periods of high flows, most likely in late winter and spring, providing minor inflows to Hattah Lakes	• Lengthy periods of high flows with major spills from storages resulting in widespread inundation of Hattah Lakes and floodplain
Potential environmental watering – tier 1 (high priorities)[1]	• Trigger-based autumn/winter partial fill of southern Hattah Lakes • Trigger-based winter/spring fill of Lake Kramen	• Autumn/winter partial fill of southern Hattah Lakes • Winter/spring fill of Lake Kramen	• Autumn/winter partial fill of southern Hattah Lakes • Winter/spring fill of Lake Kramen	• N/A
Potential environmental watering – tier 2 (additional priorities)	• N/A	• N/A	• N/A	• Natural inundation of Hattah Lakes including Lake Kramen may be supplemented by pumping
Possible volume of water for the environment required to achieve objectives[2]	• 32,000 ML (tier 1)	• 32,000 ML (tier 1)	• 32,000 ML (tier 1)	• 0–100,000 ML (tier 2)

1 *It is not possible to distinguish between tier 1a and 1b demands for Hattah Lakes as there is no individual entitlement (and therefore no expected supply volume) for them. Rather the water is shared and prioritised across several systems.*

2 *Water for the environment requirements for tier 2 are additional to tier 1 requirements.*

8 *Observations of tree health will be used as a management trigger at Lake Kramen. Watering will occur under a drought scenario, if there is risk that five percent of the river red gum or black box fringing Lake Kramen will die.*

5.2.5 Lower Murray wetlands

System overview

The lower Murray wetlands are found across the floodplain of the River Murray between Swan Hill and the South Australian border. The system includes a myriad of interconnected creeks, wetlands and floodplains that are ecologically important and reflect the natural character and attributes of the River Murray floodplain. While the number of wetlands across the lower Murray region are in their hundreds, 66 of them are considered part of the environmental watering program, and 54 of these have received water for the environment to date.

Regulation and diversion of River Murray flows have substantially reduced the frequency and duration of the high river flows that would naturally water the lower Murray wetlands. This change to the water regime has reduced the variety and condition of environmental values associated with billabongs and other floodplain habitats.

Water for the environment can be delivered to some wetlands in the region by direct pumping from the River Murray and/or use of irrigation supply infrastructure. Most wetlands that receive environmental flows can be managed independently of each other.

Some wetlands in the lower Murray area can receive water through weir-pool manipulation, for improved environmental outcomes. However, because they do not receive held water for the environment, they are not specified in this plan. Details of the environmental objectives associated with those wetlands can be found in the Mallee CMA's *Seasonal Watering Proposal for the Lower Murray Wetlands 2019–20*.

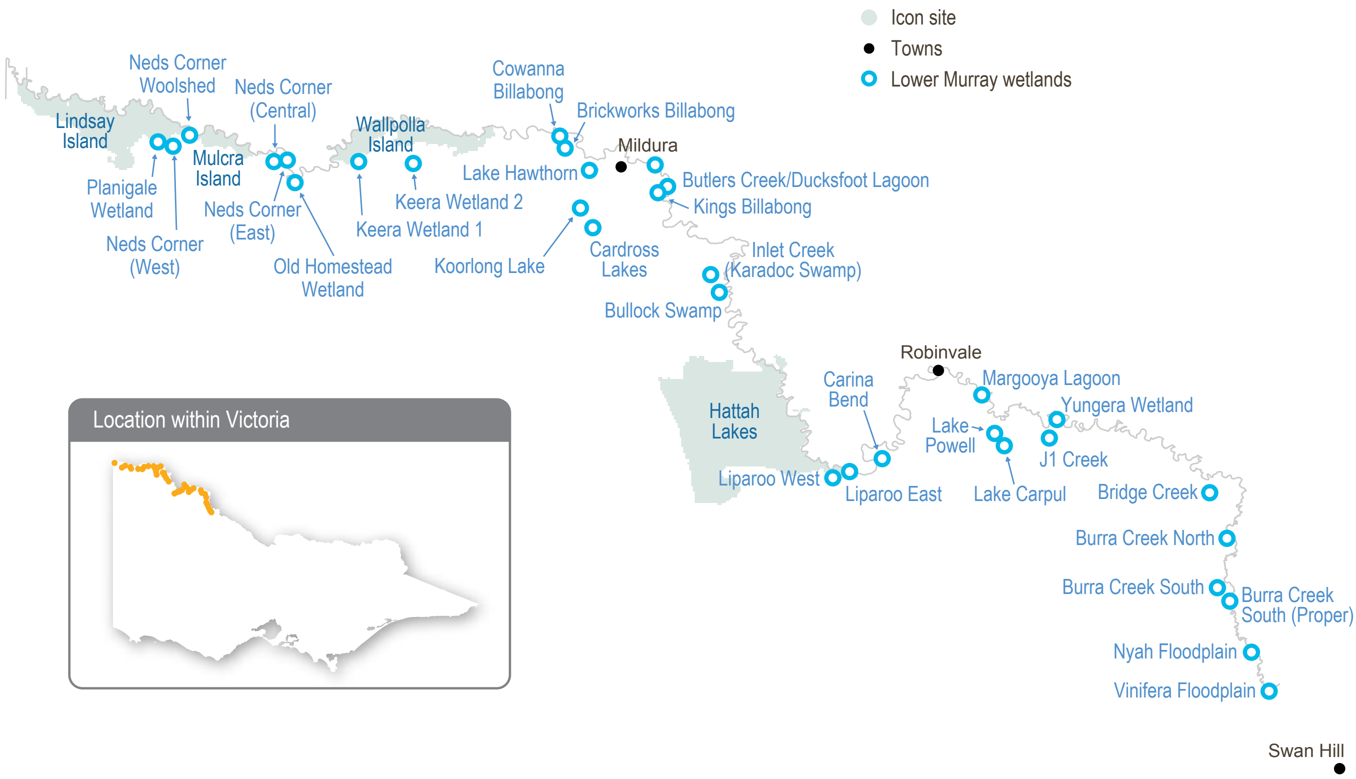
Environmental values

The lower Murray wetlands are comprised of multiple wetlands, creeks and billabongs. Depending on their location in the landscape, interactions with groundwater and their management history, the wetlands may be permanent or temporary, freshwater or saline. Differences in water regime and water quality between the wetlands provide a range of habitats for plants and animals. For example, permanent, saline wetlands (such as Brickworks Billabong) provide vital habitat for the endangered Murray hardyhead fish. Ephemeral wetlands support different ecological processes in their wet and dry phases. During the wet phase, they provide short-term boom periods when river red gum trees and wetland plants grow, spread and provide habitat for aquatic animals (such as waterbugs, birds, frogs and in some cases fish). During the dry phase, sediments are exposed to the air (which is important for carbon and nutrient cycles), and terrestrial plants grow and complete life cycles.

Environmental objectives in the lower Murray wetlands

Maintain and/or grow populations of native fish in permanent wetlands
Maintain and/or grow populations of native frogs including the endangered growling grass frog
Provide habitat for large terrestrial animals (such as lace monitors and bats)
Maintain and/or grow populations of native freshwater turtles including the endangered broad-shelled turtle
Increase the diversity, extent and abundance of wetland plants Improve the condition of river red gums, black box and lignum
Provide feeding and breeding habitat for a range of waterbird species including threatened and migratory species and colonial nesting species (such as egrets)

Figure 5.2.4 The lower Murray wetlands



Recent conditions

The lower Murray wetlands area experienced lower-than-average rainfall and higher-than-average temperatures in 2018–19. Although local rainfall is a contributing factor, flows in the River Murray primarily determine the inundation frequency and duration of the lower Murray wetlands. A small pulse in the River Murray in October 2018 inundated some of the low-lying wetlands in the area, but the flow was not sufficient to inundate any of the wetlands specified in the *Seasonal Watering Plan 2018–19*.

Environmental watering was managed under a dry scenario throughout 2018–19, prioritising watering actions that aimed to protect and maintain environmental values, avoid critical losses and maintain key refuges and key ecosystem functions at high-priority wetlands.

Water for the environment was delivered to nine wetlands in the lower Murray system. Most of this water was used to partially or completely fill wetlands in spring. Prolonged high temperatures over spring/summer resulted in increased evaporation, and water levels declining faster than normal. Top-ups were provided as needed to Lake Hawthorn, Koorlong Lake and Brickworks Billabong, to maintain water quality and ruppia aquatic habitat for Murray hardyhead.

Water for the environment was delivered to Lake Hawthorn in spring 2018 to provide optimal conditions for about 600 captive-bred Murray hardyhead that were released into the lake. Competing water demands prevented subsequent top-ups to the lake in January 2019: water for the environment uses the existing irrigation network for delivery and is subject to interruptible supply to meet irrigation demands. Monitoring in 2019 will determine if spawning and recruitment has been successful.

Following spring fills, the regulators to both Butlers Creek and Ducksfoot Lagoon were closed, allowing the wetlands to draw down over summer and autumn. Drying of the wetlands will help control local populations of carp. A large number of waterbirds including spoonbills and egrets were observed at both wetlands, after the wetlands filled and as they drew down.

In autumn, water for the environment was delivered to Lake Hawthorn, Burra Creek North, Burra Creek South and Vinifera floodplain. Except for Lake Hawthorn, these wetlands were allowed to completely dry over spring/summer. Drying killed carp that had moved into the wetlands and allowed clays in the bed of the wetlands to crack, which provided habitat for insects, reptiles and small mammals and allowed carbon/nutrients to accumulate in the soil. The input of carbon and nutrients during the dry phase will lead to increased productivity when the wetlands are next watered.

Scope of environmental watering

Table 5.2.9 describes the potential environmental watering actions that may be delivered in 2019–20, their functional watering objectives (that is, the intended physical or biological effect of the watering action) and the longer-term environmental objective they support. Each environmental objective relies on one or more potential environmental watering actions and their associated physical or biological functions.

Environmental watering in 2019–20 will focus on maintaining critical wetland habitat for native animals by maintaining water quality, which helps create refuge, breeding and feeding habitat.

Table 5.2.9 Potential environmental watering actions and objectives for the lower Murray wetlands

Potential environmental watering action	Functional watering objective	Environmental objective
Wetland watering		
Brickworks Billabong (fill in spring, with top-ups as required to maintain water quality and water level targets)	• Fill in spring to 34.0 m AHD to inundate and grow ruppia to provide nursery habitat for Murray hardyhead and to provide high levels of aquatic productivity • Allow natural recession of a maximum 1 m AHD in late summer/autumn (to 33.0 m AHD), to provide shallow-water habitat and expose mudflats to support foraging and resting of small waders	
Bridge Creek (fill in winter/spring)	• Inundate existing river red gum, black box and lignum to maintain/improve their condition	
Bullock Swamp North (fill in winter/spring)	• Increase aquatic macrophyte diversity and area in the freshwater marsh habitats	
Burra Creek North (fill in winter/spring)	• Inundate existing river red gum, black box and lignum to maintain/improve their condition • Promote the growth of seasonal emergent and semi-emergent macrophytes • Provide seasonal connectivity along Burra Creek, wetlands and the floodplain in the target area to increase opportunities for native frogs and turtles and maintain riverine food chains	

Table 5.2.9 Potential environmental watering actions and objectives for the lower Murray wetlands *continued...*

Potential environmental watering action	Functional watering objective	Environmental objective
Burra Creek South (fill in winter/spring)	• Inundate existing river red gum, black box and lignum to maintain/improve their condition • Promote the growth of seasonal emergent and semi-emergent macrophytes • Provide seasonal connectivity along Burra Creek, wetlands and the floodplain to increase the movement of turtles to support their recruitment and long-term population growth	
Burra Creek South Proper (fill in winter/spring)	• Inundate existing fringing river red gum, black box and lignum to maintain/improve their condition • Promote the growth of seasonal emergent and semi-emergent macrophytes	
Carina Bend (fill in winter/spring)	• Inundate the existing mature river red gum trees along the wetland perimeter to maintain their health • Inundate the floodway pond herbland EVC[1] within the creek to provide seasonal aquatic habitat that supports a diverse population of native fish and frogs • Inundate the intermittent swampy woodland EVC[1] to provide nesting and feeding habitat for waterfowl in winter and spring	
J1 Creek (fill in winter/spring)	• Inundate the existing river red gum communities to improve their health • Inundate the floodplain to increase the recruitment of floodplain plant communities including river red gum, lignum and black box	
Koorlong Lake (top-ups as required to maintain water quality and water level targets)	• Fill wetland to 38.0 m AHD in spring to support the growth of ruppia, to provide nursery habitat for Murray hardyhead and provide high levels of aquatic productivity • Allow water levels to drop over summer to 36.7 m AHD to increase salinity levels, providing a competitive advantage to Murray hardyhead	
Lake Carpul (fill in winter/spring)	• Inundate trees (including river red gum) bordering creeks and lakes to improve their condition • Fill Lake Carpul to capacity to support water-dependent vegetation and increase understorey productivity	
Lake Hawthorn (fill in spring, with top-ups as required to maintain water quality and water level targets)	• Fill wetland to 33.3 m AHD to encourage the germination and growth of ruppia, to provide nursery habitat for Murray hardyhead and visitation by shorebirds • Allow natural recession of a maximum 0.3 m (to 33.0 m AHD) to expose mudflats for foraging shorebirds before providing a top-up volume to return the water level to 33.3 m AHD	
Lake Powell (fill in winter/spring)	• Inundate trees (including river red gum) bordering creeks and lakes to improve their condition • Fill Lake Powell to capacity to support water-dependent vegetation and increase understorey productivity	
Liparoo East Billabong (fill in winter)	• Fill the billabong to encourage lignum growth and provide feeding habitat for large waders as well as temporary breeding habitat for waterbirds • Fill the billabong to support the growth of native vegetation and increase the understorey diversity and recruitment of river red gum saplings	
Liparoo West Billabong (fill in winter)	• Fill the billabong to encourage lignum growth and provide feeding habitat for large waders as well as temporary breeding habitat for waterbirds • Fill the billabong to support the growth of native vegetation and maintain a community of drought-tolerant emergent aquatic macrophytes at the wetland edge	

Table 5.2.9 Potential environmental watering actions and objectives for the lower Murray wetlands *continued...*

Potential environmental watering action	Functional watering objective	Environmental objective
Neds Corner Central (fill in spring/summer)	• Fill the wetland to inundate the lignum swamp zone to stimulate the recruitment of native vegetation and improve species diversity • Fill the wetland to encourage lignum growth and increase the quantity and quality of nesting habitat for waterbirds	
Neds Corner East (fill in spring/summer)	• Fill the wetland to inundate the floodway pond herbland zone, to stimulate the recruitment of native vegetation and improve species diversity • Improve vegetation recruitment and diversity to meet EVC[1] benchmarks • Maintain the health and structure of the shrubby riverine woodland EVC[1]	
Neds Corner Woolshed (fill in winter/spring)	• Inundate the creek bed to enhance floodplain productivity and provide increased foraging areas to support the growling grass frog population • Fill the creek to increase the recruitment of river red gums and understory shrubs to improve breeding and nesting opportunities for native waterbirds	
Nyah Floodplain (fill in spring/summer)	• Water seasonal anabranches to restore the vegetation structure of wetland plant communities • Fill seasonal wetlands to re-establish resident populations of native frogs and support terrestrial animals • Inundate the red gum swamp forest and woodland to increase the recruitment of river red gum saplings and provide reliable breeding habitat for waterbirds including colonial nesting species • Deliver water onto the floodplain to improve the vegetation condition and support resident populations of vertebrate animals including carpet python, sugar glider and grey-crowned babbler	
Vinifera Floodplain (fill in spring/summer)	• Water seasonal anabranches to restore the vegetation structure of wetland plant communities • Fill seasonal wetlands to re-establish resident populations of native frogs and support terrestrial animals • Inundate the red gum swamp forest and woodland to increase the recruitment of river red gum saplings and provide reliable breeding habitat for waterbirds including colonial nesting species • Deliver water onto the floodplain to improve the vegetation condition and support the resident populations of vertebrate animals including carpet python, sugar glider and grey-crowned babbler	
Yungera Wetland (fill in winter/spring)	• Inundate the existing river red gum communities to improve their health • Inundate the floodplain to increase the recruitment of floodplain plant communities including river red gum, lignum and black box	
Wetland drying		
Margooya Lagoon	• Allow the lagoon to naturally recede and dry, to remove carp from the system and allow soils to consolidate and crack, to promote nutrient cycling. This promotes high levels of aquatic productivity upon rewetting, which support native frogs, fish recruitment and a range of habitat for waterbird feeding and breeding	

[1] *Ecological Vegetation Classes (EVCs) are the standard unit for classifying vegetation types in Victoria. EVCs are described through a combination of floristics, lifeforms and ecological characteristics, and through an inferred fidelity to particular environmental attributes. Each EVC includes a collection of floristic communities (that is, lower level in the classification) that occur across a biogeographic range, and although differing in species, have similar habitat and ecological processes operating.*

Scenario planning

Table 5.2.10 outlines the potential environmental watering and expected water use under a range of planning scenarios.

The highest-priority wetlands for environmental watering in 2019–20 under all climate scenarios, and particularly in a drought scenario, are those that provide critical refuge for native animals, including the critically endangered Murray hardyhead. As water availability increases, proposed watering extends to those wetlands that comprise a range of important vegetation communities, which provide breeding and feeding habitat for a diverse array of native species. Priority is given to those wetlands where the vegetation community has not been inundated for one or more years and is unlikely to withstand another dry year.

Depending on seasonal conditions and water availability, water deliveries to remaining wetlands are prioritised considering their recommended water regimes and the condition of the environmental values at each site. Under wetter scenarios, additional wetlands will be watered to mimic conditions that would naturally occur. In this way, the environmental responses are optimised, as plants and animals respond to natural environmental cues.

Table 5.2.10 Potential environmental watering for the lower Murray wetlands under a range of planning scenarios

Planning scenario	Drought	Dry	Average	Wet
Expected catchment conditions	• No unregulated flows in the River Murray year-round and wetlands rely on delivery of water for the environment; very low rainfall year-round and extremely hot and dry conditions in summer/autumn causes substantial wetland drying	• Short periods of high flows in the River Murray are possible, however overbank flows to wetlands do not occur; low rainfall and very warm summer/autumn	• Sustained periods of high flows in the River Murray in late winter and early spring will provide some opportunity for low-lying wetlands to be naturally inundated but most wetlands will still rely on delivery of water for the environment • Local rainfall may be high and provide catchment flows to some wetlands	• Lengthy periods of high flows and floods with major spills from storages, resulting in widespread inundation of the floodplain and most wetlands • Some reliance on water for the environment to achieve target water levels • Local rainfall may be high and will provide catchment flows to most wetlands
Potential environmental watering – tier 1 (high priorities)[1]	• Brickworks Billabong • Lake Hawthorn • Koorlong Lake	• Brickworks Billabong • Lake Hawthorn • Koorlong Lake • Neds Corner East • Neds Corner Central • Neds Corner Woolshed • Liparoo East Billabong • Liparoo West Billabong • Carina Bend • Bridge Creek	• Brickworks Billabong • Lake Hawthorn • Koorlong Lake • Neds Corner East • Neds Corner Central • Neds Corner Woolshed • Liparoo East Billabong • Liparoo West Billabong • Carina Bend • Bridge Creek	• Brickworks Billabong • Lake Hawthorn • Koorlong Lake • Neds Corner East • Neds Corner Central • Neds Corner Woolshed • Liparoo East Billabong • Liparoo West Billabong • Carina Bend • Bridge Creek

Table 5.2.10 Potential environmental watering for the lower Murray wetlands under a range of planning scenarios *continued...*

Planning scenario	Drought	Dry	Average	Wet
Potential environmental watering – tier 2 (additional priorities)	• N/A	• N/A	• Burra Creek North • Burra South • Lake Powell • Lake Carpul	• Burra Creek North • Burra South • Lake Powell • Lake Carpul • Burra South Proper • Nyah Floodplain • Vinifera Floodplain • Yungera • J1 Creek • Bullock Swamp
Possible volume of water for the environment required to achieve objectives[2]	• 1,900 ML (tier 1)	• 5,120 ML (tier 1)	• 5,120 ML (tier 1) • 7,000 ML (tier 2)	• 5,120 ML (tier 1) • 11,520 ML (tier 2)

1 *It is not possible to distinguish between tier 1a and 1b demands for the central Murray wetlands as there is no individual entitlement (and therefore no expected supply volume) for them. Rather the water is shared and prioritised across several systems. Instead, watering actions are listed in priority order. Wetlands are listed in priority order for tier 1 and tier 2 under all climate scenarios.*

2 *Water for the environment requirements for tier 2 actions are additional to tier 1 requirements.*

5.2.6 Lindsay, Mulcra and Wallpolla islands

System overview

Lindsay, Mulcra and Wallpolla islands cover over 26,100 ha of Victorian floodplain in the Murray-Sunset National Park, as Figure 5.2.5 shows. They form part of the Chowilla Floodplain and Lindsay-Wallpolla islands icon site that straddles the Victoria and South Australia border in the mid-Murray river system.

The Lindsay, Mulcra and Wallpolla islands floodplain is characterised by a network of permanent waterways, small creeks and wetlands. The Lindsay River, Potterwalkagee Creek and Wallpolla Creek form the southern boundaries of the site and create large floodplain islands with the River Murray to the north.

In their natural state, these waterways and wetlands would regularly flow and fill in response to high water levels in the River Murray. Large floods still occur, but major storages in the upper reaches of the River Murray system have reduced the frequency of small- to moderate-sized floods.

Flows in the mid-Murray river system are regulated through a series of weir pools, generally referred to as locks. Water levels in the weir pools are managed primarily to provide safe navigation and adequate water levels for off-stream diversion via pumps. In recent years, the water level of weir pools 7 and 8 has also been managed to achieve ecological benefits in the River Murray channel, for example by lowering pool levels to increase the extent of fast-flowing habitat, which is preferred by large-bodied native fish (such as Murray cod).

Weir pool levels have a big effect on flows in Mullaroo Creek, the Lindsay River and Potterwalkagee Creek. When water levels in locks 7 and 8 are raised above the full supply level (FSL), flows to the Lindsay River and Potterwalkagee Creek increase; when weir pools are lowered, flows to both the Lindsay and Potterwalkagee reduce and eventually they stop flowing. Mullaroo Creek is less-affected by weir pool levels, because flows are controlled through the Mullaroo Creek regulator which connects the creek and the River Murray. Moderate lowering of the lock 7 weir pool level has little effect on Mullaroo Creek, but lowering to or beyond 0.5 m below FSL makes it difficult to deliver the recommended minimum flow of 600 ML per day that is required for native fish.

Fluctuation of weir pool levels is a major management consideration for jurisdictions that manage flows in the River Murray and the anabranch waterways of Lindsay, Mulcra and Wallpolla islands. Environmental objectives and associated water regimes for the River Murray sometimes conflict with those for the Lindsay, Mulcra and Wallpolla anabranch systems, so responsible agencies in Victoria and NSW and the Murray-Darling Basin Authority need to collaboratively plan how to manage weir pools and flows effectively.

Environmental values

The Lindsay, Mulcra and Wallpolla islands represent three separate anabranch systems including streams, billabongs, large wetlands and swamps. When flooded, waterways and wetlands within these systems provide habitat for native fish, frogs, turtles and waterbirds. Terrestrial animals (such as woodland birds) also benefit from improved productivity and food resources when the system floods. Large floodplain wetlands (such as Lake Wallawalla) can retain water for several years after inundation, and they provide important refuge for wetland-dependent species and support terrestrial animals (such as small mammals and reptiles).

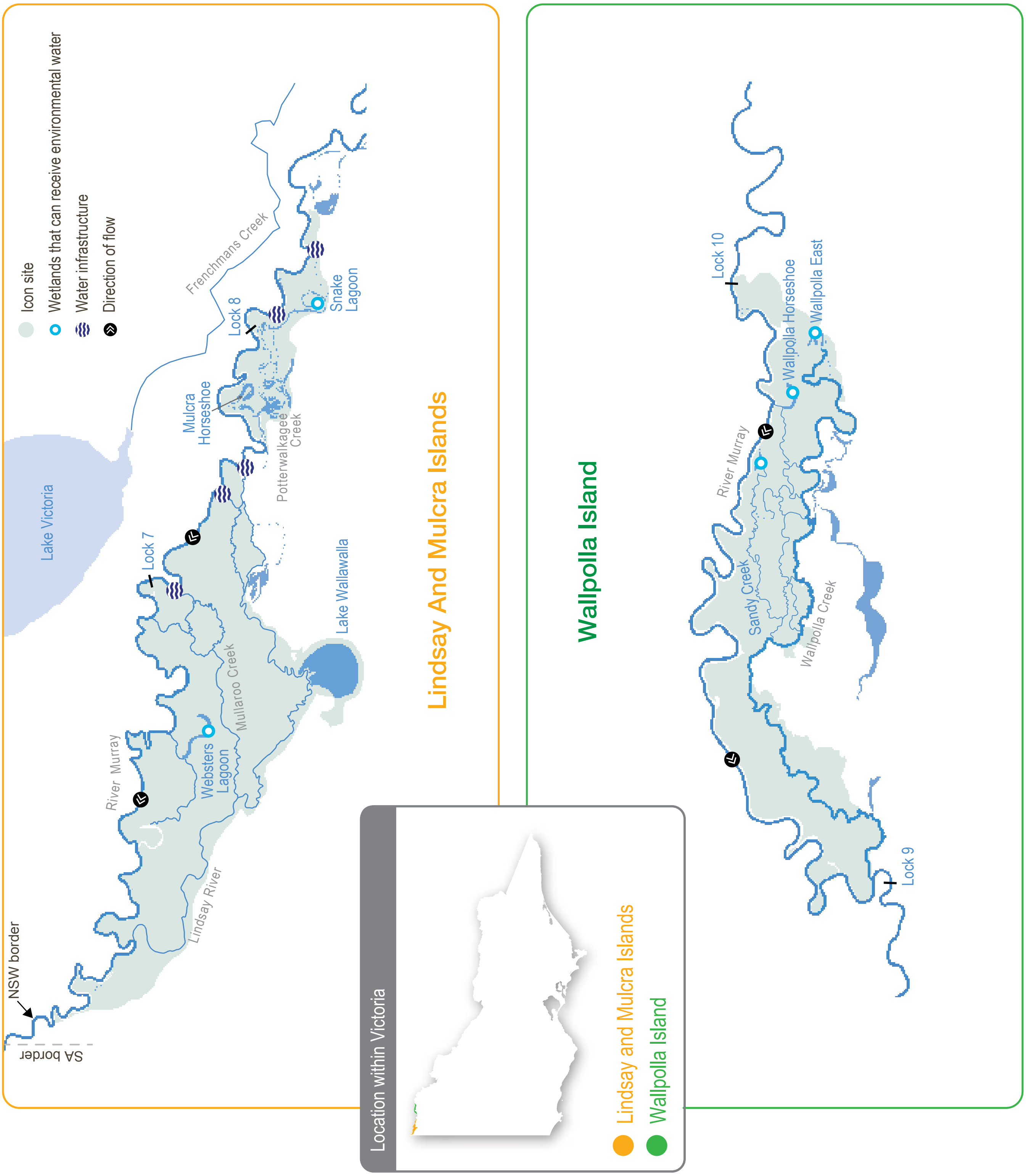
Mullaroo Creek and the Lindsay River support one of the most-significant populations of Murray cod in the lower River Murray. These waterways provide fast-flowing habitat that Murray cod favour, and contrast with the mostly slow-flowing and still habitats created by the nearby River Murray weir pools. Mature breeding fish in Mullaroo Creek and Lindsay River produce juveniles that subsequently colonise other parts of the Murray system. Waterways and wetlands throughout the icon site support several other fish species including freshwater catfish, silver perch, Murray-Darling rainbowfish and unspecked hardyhead.

The reduced frequency and duration of floods in the River Murray has degraded the water-dependent vegetation communities throughout the Lindsay, Mulcra and Wallpolla island system, which has in turn reduced the diversity and abundance of animals that rely on healthy vegetation for habitat.

Environmental watering objectives for the Lindsay, Mulcra and Wallpolla islands

	Increase the abundance, diversity and distribution of native fish
	Increase the abundance, diversity and distribution of wetland vegetation
	Increase the waterbird population by providing feeding and breeding habitat in floodplain wetlands

Figure 5.2.5 The Lindsay, Mulcra and Wallpolla islands



Recent conditions

Flows in the major Victorian and NSW tributaries of the southern Murray-Darling Basin were well-below average for the duration of 2018–19, and there was little to no inflow from the Darling River. As a result, there were no unregulated flows in the mid-Murray system in 2018–19.

The primary focus of environmental watering in the Lindsay, Mulcra and Wallpolla islands anabranch system in 2018–19 was to maintain flowing habitat in Mullaroo Creek, to help native fish survive and recruit. Flows in Mullaroo Creek varied between 400 and 1,200 ML per day throughout the year, with the higher-magnitude flows delivered in spring to support Murray cod.

The weir pool level in lock 8 was at FSL or lower all year round, which prevented any flows in Potterwalkagee Creek. The lock 7 weir pool level was too low for most of the year to provide flows to the upper Lindsay River. The exception was a short period in spring 2018 when the weir pool was raised to 0.3 m above FSL, which provided minor flows of 40 ML per day via the northern inlet. Water for the environment was delivered to Wallpolla Horseshoe, to provide feeding habitat for waterbirds and improve the condition of aquatic vegetation.

Scope of environmental watering

Table 5.2.11 describes the potential environmental watering actions that may be delivered in 2019–20, their functional watering objectives (that is, the intended physical or biological effect of the watering action) and the longer-term environmental objective they support. Each environmental objective relies on one or more potential environmental watering actions and their associated physical or biological functions.

Table 5.2.11 Potential environmental watering actions and objectives for Lindsay, Mulcra and Wallpolla islands

Potential environmental watering action	Functional watering objective	Environmental objective
Lindsay Island – Mullaroo Creek		
Year-round low flows (minimum of 600 ML/day)	• Maintain fast-flowing habitat for native fish (such as Murray cod, silver perch and golden perch)	
Spring fresh (one fresh of up to 1,200 ML/day for up to three months during September to November)	• Initiate fish movement and spawning and improve recruitment opportunities for native fish	
Winter/spring/summer high flow (one high flow of more than 1,200 ML/day for a maximum of nine months during July to March)	• Extend the duration of higher flows to support dispersal, spawning and recruitment opportunities for native fish	
Lindsay Island – Lindsay River		
Winter/spring fresh (one fresh of up to 270 ML/day via the northern regulator and up to 120 ML/day via the southern regulator for a maximum of four months during August to November)	• Provide temporary flowing habitat to support dispersal, spawning and recruitment opportunities for native fish • Inundate the substrate and debris (snags) to promote the growth of biofilms, which provide a food source for animals higher in the food chain	
Winter/spring/summer high flow (one high flow of up to 450 ML/day via the northern regulator and up to 450 ML/day via the southern regulator for a maximum of nine months during July to March)	• Extend the duration of flowing habitat to support dispersal, spawning and recruitment opportunities for native fish	

Table 5.2.11 Potential environmental watering actions and objectives for Lindsay, Mulcra and Wallpolla islands *continued...*

Potential environmental watering action	Functional watering objective	Environmental objective
Lindsay Island wetlands		
Websters Lagoon (complete fill in spring)	• Provide connection between Websters Lagoon and the River Murray to allow the exchange of carbon, nutrients and aquatic biota between the wetland and the river • Provide conditions for lake bed herbaceous plants to grow in the drawdown phase after watering • Provide variable water levels in the littoral zone to provide feeding habitat for shorebirds • Provide open-water habitat as refuge and feeding habitat for waterbirds	
Mulcra Island – Potterwalkagee Creek		
Spring fresh (one fresh of up to 450 ML/day via the Stoney Crossing regulator and up to 370 ML/day via the upper Potterwalkagee Creek regulator for a maximum of 3 months during September to November)	• Provide temporary flowing habitat to support dispersal, spawning and recruitment opportunities for native fish • Inundate the substrate and debris (snags) to promote the growth of biofilms, which provide a food source for animals higher in the food chain	
Winter/spring/summer high flow (one high flow of up to 1,000 ML/day via the Stoney Crossing and upper Potterwalkagee Creek regulators for a maximum of nine months during July to March)	• Extend the duration of flowing habitat to support dispersal, spawning and recruitment opportunities for native fish	
Wallpolla Island		
Finnigans Creek (complete fill in winter/spring) Sandy Creek (complete fill in winter/spring) Wallpolla East (complete fill in winter/spring) Wallpolla Horseshoe (partial or complete fill any time)	• Provide connection between Wallpolla East, Sandy Creek and Finnigans Creek to allow nutrient exchange, increase wetland productivity and the dispersal of plant propagules • Inundate/drown river red gum saplings in the bed of Wallpolla Horseshoe to limit their coverage • Provide variable water levels in the littoral zone to improve wetland productivity and promote the growth of native aquatic and fringing plants • Provide variable water levels in the littoral zone to provide feeding habitat for shorebirds • Provide open-water habitat as refuge and feeding habitat for waterbirds	

Scenario planning

Table 5.2.12 outlines the potential environmental watering actions and expected water use under a range of planning scenarios.

Mullaroo Creek requires year-round low flows of at least 600 ML per day under all climatic scenarios, to provide permanent habitat for large-bodied native fish, particularly Murray cod.

Under drought, dry and average scenarios, high flows are planned to be delivered to Mullaroo Creek, the Lindsay River (via the southern and northern regulators) and Potterwalkagee Creek (via Stoney Crossing and upper Potterwalkagee regulators) between August and November 2019 to cue the movement and spawning of large-bodied native fish.

Under a wet scenario, the high flows in all waterways will be extended for up to nine months between July 2019 and March 2020, to cue native fish spawning and to facilitate widespread movement between the River Murray, Lindsay River, Mullaroo Creek and Potterwalkagee Creek. It is expected these extended flows will be mostly provided by unregulated flows in the River Murray.

In summer and autumn, the water levels in lock 7 and lock 8 weir pools will be lowered to achieve environmental objectives in the River Murray. Weir pool lowering will prevent year-round low flows through the upper reaches of the Lindsay River and Potterwalkagee Creek.

Under drought, dry and average scenarios, environmental watering is planned for four wetlands at Wallpolla Island and at Websters Lagoon on Lindsay Island. In a wet scenario, long periods of high flows in the River Murray are expected to inundate large parts of the Lindsay, Mulcra and Wallpolla floodplains.

Table 5.2.12 Potential environmental watering for Lindsay, Mulcra and Wallpolla islands under a range of planning scenarios

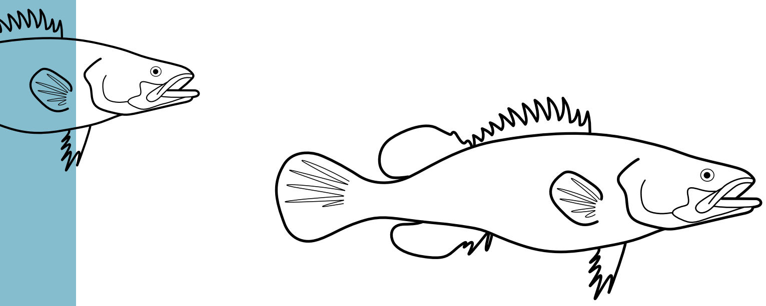
Planning scenario	Drought	Dry	Average	Wet
Expected conditions	• Year-round low flows in the River Murray and no natural floodplain inundation; substantial wetland drying will occur	• Rare high-flow events in the River Murray and no natural floodplain inundation; substantial wetland drying will occur	• Short periods of high flows, most likely in late winter and spring, providing minor inundation of the floodplain	• Long periods of high flows with major spills from storages resulting in widespread inundation of the floodplain and inundation of most wetlands
Lindsay Island				
Mullaroo Creek and Lindsay River potential environmental watering – tier 1 (high priorities)[1]	• Year-round low flows (Mullaroo Creek) • One spring fresh (Mullaroo Creek and Lindsay River) • Websters Lagoon (complete fill)	• Year-round low flows (Mullaroo Creek) • One spring fresh (Mullaroo Creek and Lindsay River) • Websters Lagoon (complete fill)	• Year-round low flows (Mullaroo Creek) • One spring fresh (Mullaroo Creek and Lindsay River) • Websters Lagoon (complete fill)	• Year-round low flows (Mullaroo Creek) • One winter/spring/summer high flow (Mullaroo Creek and Lindsay River) • Websters Lagoon (complete fill)
Possible volume of water for the environment required to achieve objectives[2]	• < 2,000 ML	• < 2,000 ML	• < 2,000 ML	• < 2,000 ML
Mulcra Island				
Potterwalkagee Creek potential environmental watering – tier 1 (high priorities)[1]	• One spring fresh	• One spring fresh	• One spring fresh	• One spring high flow

Table 5.2.12 Potential environmental watering for Lindsay, Mulcra and Wallpolla islands under a range of planning scenarios *continued...*

Planning scenario	Drought	Dry	Average	Wet
Possible volume of water for the environment required to achieve objectives[2]	• < 2,000 ML	• < 2,000 ML	• < 2,000 ML	• < 2,000 ML
Wallpolla Island				
Wallpolla Island wetlands potential environmental watering – tier 1 (high priorities) [1]	• Wallpolla Horseshoe (partial fill)	• Wallpolla Horseshoe (partial fill) • Sandy Creek (complete fill) • Wallpolla East (complete fill) • Finnigans Creek (complete fill)	• Wallpolla Horseshoe (partial fill) • Sandy Creek (complete fill) • Wallpolla East (complete fill) • Finnigans Creek (complete fill)	• All wetlands filled by unregulated flows
Potential environmental watering – tier 1 (high priorities)	• 1,000 ML	• 5,500 ML	• 5,500 ML	• 0 ML

1 Tier 1b and tier 2 objectives have not been included in scenario planning due to the relatively low volume of water required to supply all environmental watering demands at Lindsay, Mulcra and Wallpolla islands.

2 These estimates take account of the use of operational water en route to achieve watering action targets, with water for the environment being required to underwrite the associated losses in locks 7 and 8, Mullaroo Creek, Lindsay River, Potterwalkagee Creek and Websters Lagoon.



5.3 Ovens system

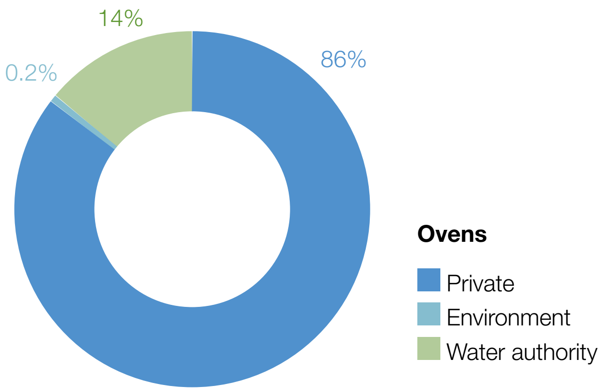
Waterway manager – North East Catchment Management Authority

Storage manager – Goulburn-Murray Water

Environmental water holder – Commonwealth Environmental Water Holder

Did you know ...?

The Ovens system is home to some of the healthiest riverbank and floodplain vegetation in Victoria, with fine examples of red gum forest and woodland thriving along river margins, benefitting from the relatively natural flow regime that persists in this system.



Proportion of water entitlements in the Ovens basin held by private users, water corporations or environmental water holders at 30 June 2018.

Top: Ovens River at Whorouly, by North East CMA
Centre: Lake Buffalo vegetation, by North East CMA
Above: Rocky river bed, Ovens River at Gapsted, by North East CMA

System overview

The Ovens River rises in the steep, forested mountains of the Great Dividing Range near Mount Hotham and flows about 150 km to join the River Murray in the backwaters of Lake Mulwala. The system contains two small water storages: Lake Buffalo on the Buffalo River and Lake William Hovell on the King River. The regulated reaches of the Ovens system include the Buffalo and King rivers downstream of these storages and the Ovens River from its confluence with the Buffalo River to the River Murray.

As its storages are quite small and spill regularly, the Ovens system maintains a large proportion of its natural flow regime, particularly in winter/spring. However, the storages and licensed water extractions throughout the system can restrict flow during low-flow periods, and parts of the system can become quite flow-stressed during summer and autumn.

The Ovens River flows into Lake Mulwala on the River Murray, the largest weir pool on the Murray regulated system. Ovens River flows contribute to the reliability and variability of the flow regime for the River Murray and support many downstream uses including irrigation, urban supply and watering of iconic floodplain sites (such as Barmah Forest).

Water for the environment is held in Lake Buffalo and in Lake William Hovell and can be released when the storages are not spilling. Five reaches in the Ovens system can benefit from releases of water for the environment. While all are important, there is a relatively small volume (123 ML) of water available, and it is well-short of the volume required to meet all environmental flow objectives. The available water is used selectively to deliver the greatest possible environmental benefit. Water for the environment is most-commonly used in the Ovens system to deliver critical flow events in reaches immediately downstream of the two main storages, or it is used in conjunction with operational water releases to influence flow in the lower Ovens River.

Environmental values

The diverse aquatic habitat and abundant food resources associated with the Ovens system support a wide range of native fish species including Murray cod, trout cod, golden perch and unspecked hardyhead. The Buffalo River provides valuable habitat for large-bodied fish species during part of their breeding cycle, while trout cod have a large range within the system and are found as far up the King River as Whitfield. A project to recover trout cod populations in the Ovens system has been successful, and efforts to reintroduce Macquarie perch are continuing.

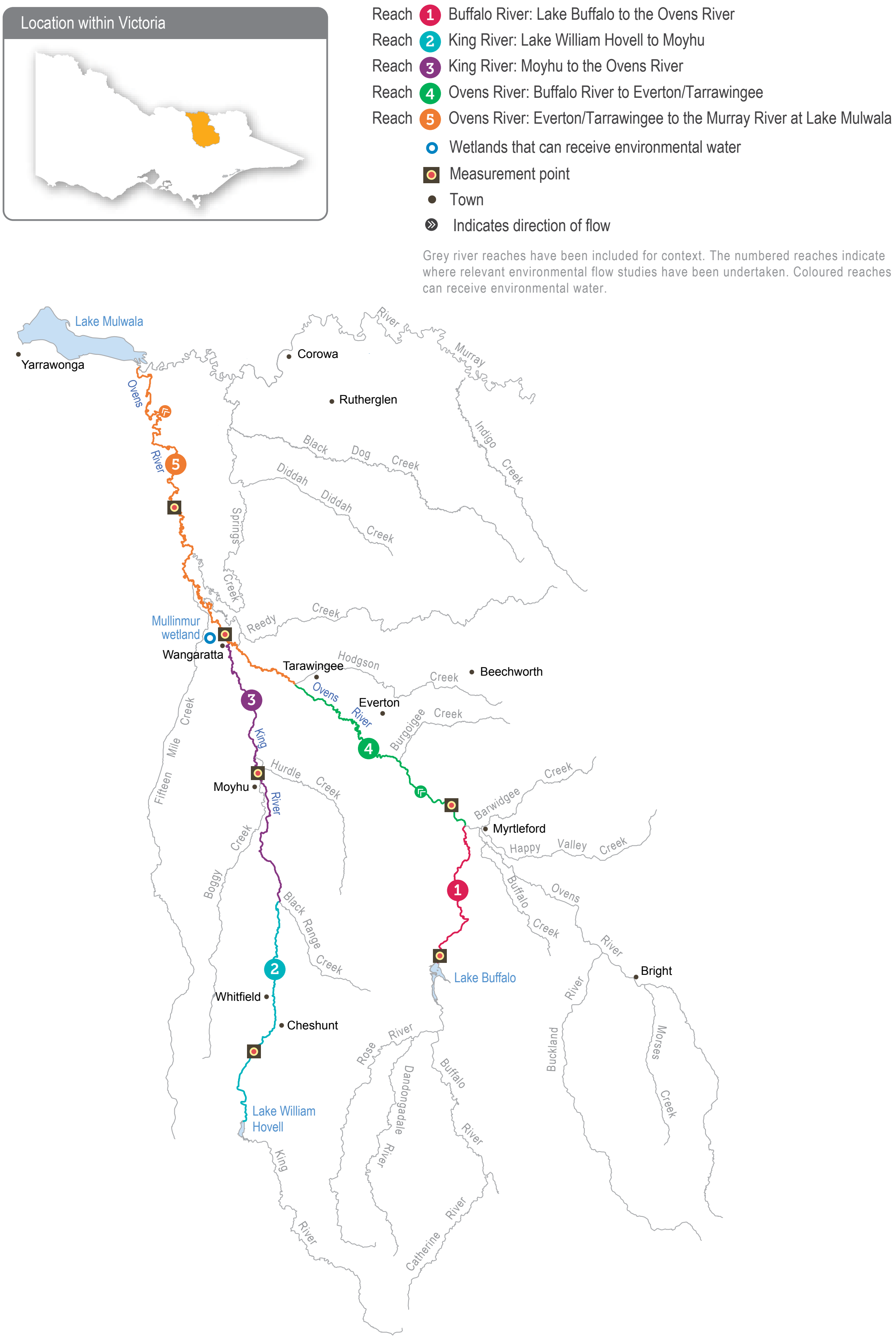
Frogs (such as the giant banjo frog and growling grass frog) are abundant in the lower reaches and associated wetlands of the Ovens River and in the King River upstream of Cheshunt. The lower Ovens wetland complex contains over 1,800 wetlands, is listed as nationally significant and is home to a variety of waterbirds including egrets, herons, cormorants and bitterns. The riparian zones of river channels throughout the Ovens system support some of Victoria's healthiest river red gum forests and woodlands, while the wetlands support a variety of aquatic and semi-aquatic vegetation communities.

The first trial delivery of water for the environment to a wetland on the Ovens floodplain is proposed for 2019–20. The target site is Mullinmur Wetland at Wangaratta, which has been the focus of several environmental improvement projects in recent years. Specific management actions include carp removal, a revegetation program and a project that is currently underway to determine whether the wetland can support a sustainable brood stock population of native freshwater catfish. Brood stock are important for catfish recovery (reintroduction) projects.

Environmental objectives in the Ovens system

Maintain the size and distribution of native fish populations
Maintain the form of the riverbank and channel and ensure river bed surfaces are in suitable condition to support all stream life
Maintain the condition and extent of wetland vegetation communities
Maintain an adequate abundance and diversity of waterbugs, to support river food webs and associated ecosystem processes
Maintain water quality for all river life

Figure 5.3.1 The Ovens system



Recent conditions

A warm and dry 2018–19 resulted in relatively low flows throughout the Ovens system. Inflows into the storages were well-below average, although both Lake William Hovell and Lake Buffalo filled. The bulk transfer of water from Lake Buffalo to the Murray that normally occurs in autumn did not proceed in 2018–19, so water for the environment was used to briefly increase low flows below the storages in autumn. These flows helped to connect habitats within the channel that can become isolated during low-flow periods, and they also improved water quality.

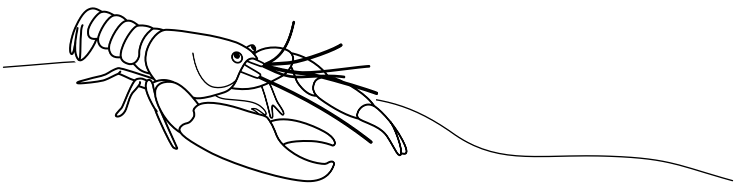
Scope of environmental watering

Table 5.3.1 describes the potential environmental watering actions that may be delivered in 2019–20, their functional watering objectives (that is, the intended physical or biological effect of the watering action) and the longer-term environmental objective they support. Each environmental objective relies on one or more potential environmental watering actions and their associated physical or biological functions.

Table 5.3.1 Potential environmental watering actions and objectives for the Ovens system

Potential environmental watering action	Functional watering objective	Environmental objective
Autumn low-flow fresh in reaches 1, 4 and 5: one fresh of ≥ 430 ML/day for three days in reaches 1 and 4, > 130–260 ML/day in reach 5 (March/April)	• Provide flow cues to stimulate the movement of native fish • Maintain connectivity between pools for fish movement • Mix pools to improve the water quality • Provide small variations in river levels and velocity, to flush sediment from hard substrates and maintain waterbug habitat • Scour biofilm from the river bed	
Summer/autumn low-flow variability[1] in reaches 1, 2 and 3	• Maintain connectivity between pools for fish movement and water quality • Provide small variations in river levels to move sediment and maintain waterbug habitat	
Mullinmur Wetland (top-up during November to February)	• Maintain the water level to support the growth and recruitment of aquatic vegetation • Maintain habitat for native catfish	

[1] *Operational releases from storage can vary, with water for the environment used to provide some variability over one or two days.*



Scenario planning

Table 5.3.2 outlines the potential environmental watering and expected water use under a range of planning scenarios.

Climatic conditions and inflows into storages have a large effect on how water for the environment is likely to be used. Under dry conditions, water for the environment aims to provide low-flow variability and avoid cease-to-flow events in the river reaches immediately below the storages. Mullinmur Wetland will also likely require water to maintain water levels and habitat for aquatic biota under dry to average conditions. As conditions become wetter, there will be more opportunities to piggyback environmental releases on operational water bulk transfers from Lake Buffalo to deliver larger freshes and achieve environmental outcomes over a much greater length of river. Water for the environment cannot be released if the storages are spilling or if there is a risk that private land will be flooded. The recommended environmental flows through the Ovens system are likely to be achieved naturally through storage spills and unregulated tributary inflows under wet conditions. The water for the environment holdings in the Ovens system have a high level of security and are expected to be fully available under all scenarios.

Table 5.3.2 Potential environmental watering for the Ovens system under a range of planning scenarios

Planning scenario	Dry	Average	Wet
Expected river conditions	• Possible winter/early spring unregulated flows • Highly likely low summer/autumn flows • Bulk water release unlikely	• High winter/spring unregulated flows • Possible summer/autumn low flows • Bulk water release likely	• High unregulated flows throughout most of the year • Bulk water release likely • All flow objectives achieved naturally
Expected availability of water for the environment	• 50 ML Lake William Hovell • 73 ML Lake Buffalo • 123 ML total		
Potential environmental watering – tier 1a (high priorities)	• Summer/autumn low flow variability • Mullinmur Wetland top-up	• Autumn fresh • Summer/autumn low flow variability • Mullinmur Wetland top-up	• None required
Possible volume of water for the environment required to achieve objectives	• 123 ML	• 123 ML	• 0 ML

5.4 Goulburn system

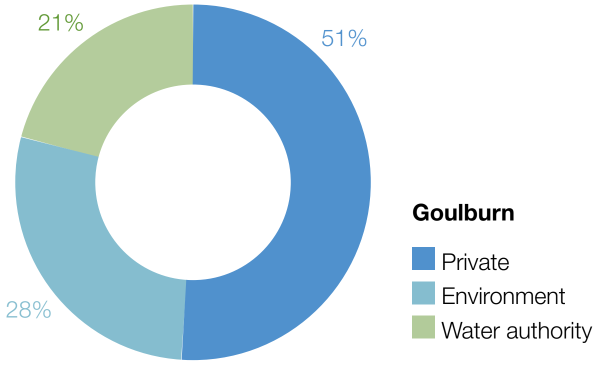
Waterway manager – Goulburn Broken Catchment Management Authority

Storage manager – Goulburn-Murray Water

Environmental water holders – Victorian Environmental Water Holder (including the Living Murray program), Commonwealth Environmental Water Holder

Did you know ...?

Taungurung people know the Goulburn River as *Waring*. The waters of *Waring* have a special connection with Taungurung, including its tributaries such as the Broken River, Hughes Creek, Seven Creeks, Yea River, Acheron River, King Parrot Creek, Rubicon River, Jamieson River, and the Howqua and Delatite rivers.



Proportion of water entitlements in the Goulburn basin held by private users, water corporations or environmental water holders at 30 June 2018.

Top: Goulburn River, by Goulburn Broken CMA
Centre: Cormorant on the Goulburn River, by Bruce Paton, VEWH
Above: River red gum, near Shepparton on the Goulburn River, by Bruce Paton, VEWH

5.4.1 Goulburn River

System overview

The Goulburn is Victoria's largest river basin, covering over 1.6 million ha or 7.1 percent of the state. The Goulburn River flows for 570 km from the Great Dividing Range upstream of Woods Point to the River Murray east of Echuca. It is an iconic heritage river because of its environmental, Aboriginal cultural heritage and recreational values.

There are several environmental water holders in the Goulburn system. The Commonwealth Environmental Water Holder holds the largest volume and use of Commonwealth water for the environment is critical to achieving outcomes in the Goulburn River, as well as priority environmental sites further downstream. Water for the environment held on behalf of the Living Murray program may assist in meeting objectives in the Goulburn system en route to icon sites in the Murray system (see subsection 1.4.2). Water held by the VEWH in the Goulburn system is used to meet environmental objectives in the Goulburn River and the Goulburn wetlands.

The construction and operation of Lake Eildon and Goulburn Weir have significantly altered the natural flow regime of the Goulburn River. Water-harvesting during wet periods and regulated releases to meet irrigation and other consumptive demands during dry periods mean that flow downstream of these structures is typically low in winter and spring and high in summer and autumn. This effectively reverses the natural seasonal flow pattern. Land use changes and the construction of small dams and drainage schemes have further modified the Goulburn River's flow regime. Levees and other structures prevent water inundating the floodplain and filling many of the natural wetlands and billabongs. If the opportunity arose to deliver water for the environment above current river thresholds at the right time to support improved environmental outcomes, water managers would consider it. Several tributaries including the Acheron and Yea rivers and the Broken River outfall downstream of Lake Eildon add some flow variation on top of the regulated flow regime in the Goulburn River. Large floods that cause the Goulburn River storages to fill and spill are also important for the overall flow regime and its associated environmental values.

The priority environmental flow reaches in the Goulburn River are downstream of Goulburn Weir (reaches 4 and 5), which are collectively referred to as the lower Goulburn River. The mid-Goulburn River extends from Lake Eildon to Goulburn Weir (reaches 1 to 3). From early spring to late autumn, large volumes of water are delivered from Lake Eildon to Goulburn Weir to supply the irrigation system. During that period, flow in the mid-Goulburn River is usually well above the recommended environmental flow targets. Deliveries of water for the environment have the most benefit in the mid-Goulburn River (especially in reach 1 immediately downstream of Lake Eildon) outside the irrigation season, when flow is much lower than natural.

Environmental flow targets can sometimes be met by the coordinated delivery of operational water being transferred from Lake Eildon to the River Murray. These transfers are known as inter-valley transfers (IVTs). These transfers occur during the irrigation season between spring and autumn, and they may meet environmental flow objectives without the need to release water for the environment. In recent years, operational transfers in the Goulburn River have significantly exceeded the environmental flow recommendations for summer and early autumn and have damaged bank vegetation and eroded the riverbanks.

Environmental values

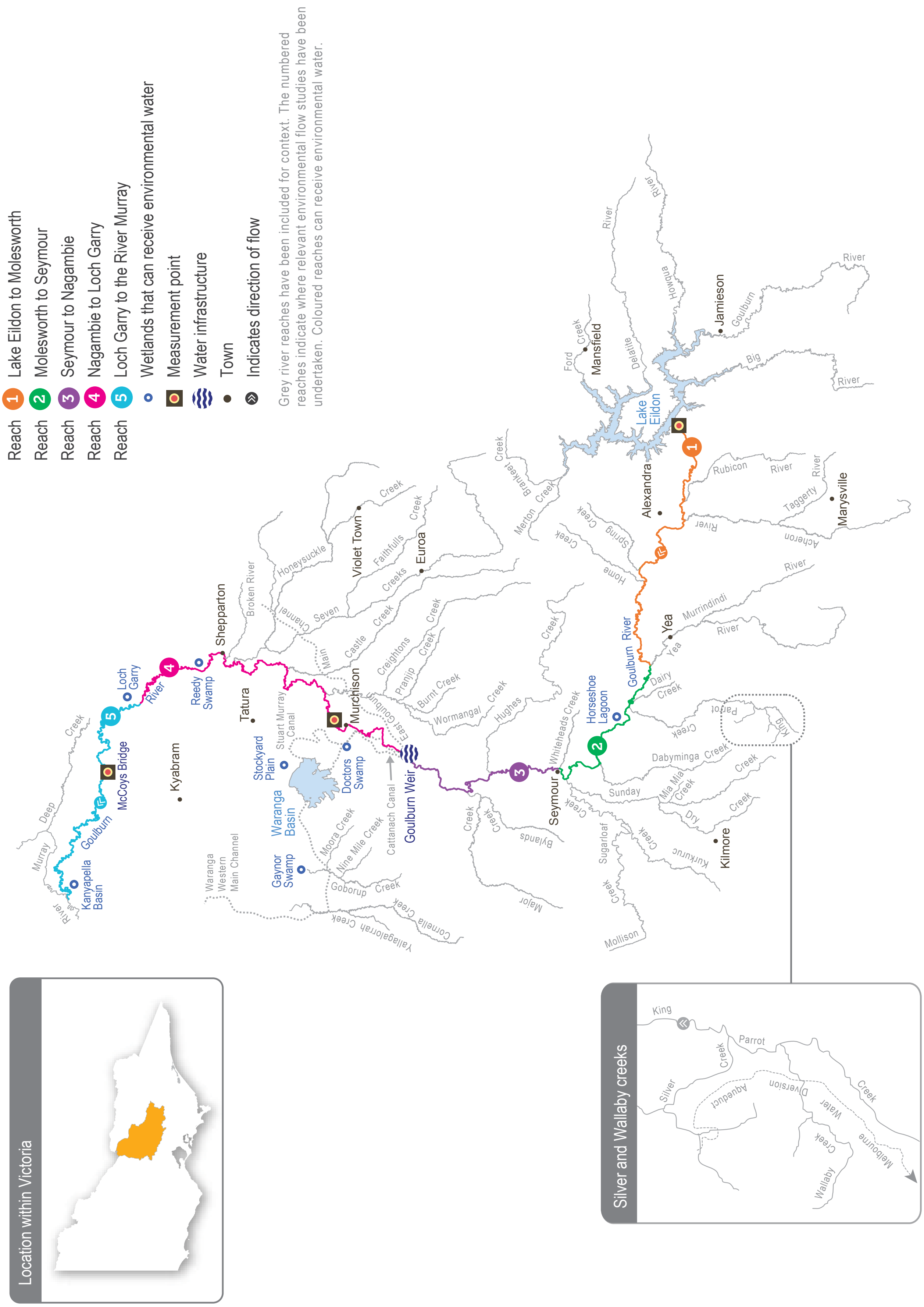
The Goulburn River and its tributaries support a range of native fish species including golden perch, silver perch, Murray cod, trout cod, Macquarie perch and freshwater catfish. Aquatic vegetation, scour holes and woody debris within the channel provide high-quality habitat for adult and juvenile fish. River red gums are a dominant feature of the riparian zone along the length of the Goulburn River. These trees shade the river and provide habitat for many species including the squirrel glider. Leaves that fall from the river red gums provide carbon that supports riverine foodwebs, and dead trees that fall into the river provide a substrate for biofilms and macroinvertebrates and habitat for fish. Birds (such as egrets, herons and cormorants) use trees along the river to roost and feed, while frogs benefit from shallowly inundated vegetation at the edge of the river channel and in adjacent wetlands.

The Goulburn River system is an important conservation area for threatened species. Several wetlands in the Goulburn catchment are formally recognised for their conservation significance. Tributaries of the mid-Goulburn River between Lake Eildon and Goulburn Weir host some of the last remaining Macquarie perch populations in the Murray-Darling Basin, while freshwater catfish can be found in lagoons connected to reach 3 of the Goulburn River. Monitoring over recent years shows that environmental flows in the lower Goulburn River can trigger golden perch, silver perch and trout cod to spawn. However, these larvae do not appear to survive or remain in the Goulburn River and contribute to the local population.

Environmental objectives in the Goulburn River

Protect and boost populations of native fish
Maintain the form of the riverbank and channel including maintaining a high diversity of river bed surfaces to support all stream life
Provide sufficient rates of carbon and nutrient production and processing, to support native fish and waterbug communities
Increase aquatic and flood-tolerant plants in the river channel and on the lower banks, to provide shelter and food for animals and to stabilise the riverbank
Maintain abundant and diverse waterbug communities, to support the riverine foodweb
Minimise the risk of hypoxic blackwater after natural events

Figure 5.4.1 The Goulburn system



Recent conditions

The Goulburn catchment has experienced drier-than-average conditions for most of the last six years. The main exception was 2016, when unregulated spring flows caused overbank flooding. This preceded another very dry summer and autumn in 2016–17, and since then the trend has been dry.

In the lower Goulburn River, most of the flow variation in 2018–19 was due to releases of water for the environment and IVTs, rather than natural (unregulated) flows. An exception was one small, unregulated flow event in August 2018, which reached about 1,500 ML per day at Murchison and 2,000 ML per day at McCoys Bridge. Water for the environment was used when necessary throughout the year to meet minimum low-flow requirements and to provide some high flows in winter and spring to support specific environmental outcomes.

Water for the environment was used to deliver a winter fresh in mid-June to mid-July 2018 to improve the bank vegetation, water quality and habitat for waterbugs and native fish. Improving the condition of the bank vegetation in winter/spring increases the resilience of plant communities and enables them to better withstand the effects of high river flows in the following summer and autumn. The VEWH is funding the Goulburn Broken CMA to undertake a monitoring project to investigate the impact of high summer and autumn flows in 2018–19. The outcomes of this project will inform future management decisions to improve environmental outcomes.

A combination of water for the environment and IVTs was used to deliver a spring fresh from late September to late October 2018, to allow the bank vegetation to establish and grow. Healthy bank vegetation helps to protect the riverbank from erosion, and vegetation at the water's edge provides habitat for waterbugs and small fish.

In late August 2018, an IVT pulse up to 3,000 ML per day was delivered down the Goulburn River, which is the earliest an IVT has ever been delivered in the water year. IVT demand increased in mid-December 2018 and after Christmas, and releases from the Goulburn Weir near Murchison remained above 2,000 ML per day throughout January and February 2019. From late February and for the first week of March 2019, the river flow dropped to about 1,000 ML per day before again increasing above 2,000 ML per day as autumn irrigation demands increased. The total volume of IVT delivered down the Goulburn River in 2018–19 was the highest on record, and has tripled over the last four years. The duration of IVT has also increased in the last two years, with releases starting as early as August and ending as late as June.

A study commissioned in 2018 recommended that flow in the lower Goulburn River should not exceed 1,000 ML per day for more than a few weeks in spring and summer/autumn, to protect the bank vegetation. Despite collaboration between the Goulburn Broken CMA and Goulburn-Murray Water to try to limit environmental damage, it was not possible to achieve these flow recommendations and also supply downstream consumptive demand in 2018–19.

The vast majority of water for the environment delivered in the Goulburn River is reused at downstream sites along the River Murray. In 2018–19, Goulburn water was reused to meet native fish objectives in Gunbower Creek, inundate wetlands and significant floodplain habitats in Gunbower Forest and support ecological objectives in South Australia. Water for the environment that is delivered from the Goulburn system makes a significant contribution to environmental objectives further downstream, which helps to achieve environmental outcomes at the Murray-Darling Basin scale.

Scope of environmental watering

Table 5.4.1 describes the potential environmental watering actions that may be delivered in 2019–20, their functional watering objectives (that is, the intended physical or biological effect of the watering action) and the longer-term environmental objective they support. Each environmental objective relies on one or more potential environmental watering actions and their associated physical or biological functions.

Table 5.4.1 Potential environmental watering actions and objectives for the Goulburn River

Potential environmental watering action	Functional watering objective	Environmental objective
Winter fresh (during July to August 2019, up to 15,000 ML/day with more than 14 days above 6,600 ML/day in reaches 4 and 5)	• Improve macroinvertebrate habitat by improving water quality (reducing turbidity and mixing stratified water) and by increasing the wetted perimeter • Provide carbon (e.g. leaf litter) to the channel • Inundate bench habitats to encourage plant germination • Remove terrestrial vegetation and trigger the recruitment of native bank vegetation	
Year-round low flows (500–830 ML/day in reach 4 and 540–940 ML/day in reach 5)	• Provide slow, shallow habitat required for recruitment of larvae/juvenile fish and habitat for adult small-bodied fish • Provide deep-water habitat for large-bodied fish • Submerge snags to provide habitat for fish and waterbugs and a substrate for biofilms to grow • Maintain habitat for aquatic vegetation and water the root zone of low bank vegetation • Vary flow within a specified range to encourage planktonic production (for food), disrupt biofilms and maintain water quality	
Winter/spring variable low flows (between 800–2,000 ML/day in reach 4 during July to October)	• Increase sediment and seed deposition on banks and benches • Support nutrient cycling	
Spring/autumn/winter low flows (400 ML/day in reach 1 during July to September and April to June)	• Wet and maintain riffles to provide habitat for biofilms and waterbugs • Scour fine sediment from the gravel bed and riffle substrate • Maintain the wetted perimeter of the channel and habitat for aquatic vegetation • Maintain existing beds of in-channel vegetation • Maintain habitat for small-bodied native fish	
Spring fresh (> 6,000 ML/day for 14 days in August – September in reaches 4 and 5)	• Inundate and water vegetation on the benches and lower banks, to support existing plants and facilitate recruitment • Increase soil moisture on the benches and banks, to sustain growth and increase vigour, flowering and seed development • Increase the extent of vegetation by distributing seed to riverbanks	
Flows should not exceed 1,000 ML/day for five to six weeks after a spring fresh (in late spring and summer) in reaches 4 and 5	• Allow newly grown littoral emergent and amphibious plants to become established and persist • Provide bank stability • Provide habitat for small-bodied fish and macroinvertebrates	
Provide slower recession to unregulated flows, or add pulses following natural cues/unregulated flows (in reaches 1 and 4)	• Minimise the risk of bank erosion associated with rapid drawdown • Minimise the risk of hypoxic blackwater after natural events	

Table 5.4.1 Potential environmental watering actions and objectives for the Goulburn River *continued...*

Potential environmental watering action	Functional watering objective	Environmental objective
Winter fresh (in 2020, up to 15,000 ML/day with more than 14 days above 6,600 ML/day in reaches 4 and 5)	• Improve macroinvertebrate habitat by improving water quality (reducing turbidity and mixing stratified water) and by increasing the wetted perimeter • Provide carbon (e.g. leaf litter) to the channel • Inundate bench habitats to encourage plant germination • Remove terrestrial vegetation and trigger the recruitment of native bank vegetation	
Autumn fresh (one fresh of up to 6,000 ML/day for two days in March or April in reaches 4 and 5)[1]	• Encourage the germination of new seed on the lower banks and benches • Improve water quality by reducing turbidity and mixing stratified water • Flush fine sediment from hard substrates to allow new biofilm growth and to improve food and habitat for macroinvertebrates	
Flows should not exceed 1,000 ML/day for more than 20 consecutive days, with a minimum of seven days between pulses in summer/ autumn in reaches 4 and 5	• Maintain for more than one season a littoral fringe of emergent or amphibious plants • Provide bank stability • Provide habitat for small-bodied fish and macroinvertebrates	

1 *This autumn fresh will only be delivered if the average weekly flows in summer are less than 1,500 ML/day.*

Scenario planning

Table 5.4.2 outlines the potential environmental watering and expected water use under a range of planning scenarios.

Various triggers for action are applied as part of the adaptive management of water for the environment in the Goulburn system. For example, carrying over water to provide low flows in winter and spring 2020 is only required in below-average, dry or drought conditions to enable low flows to continue from the 2019–20 water year into July to September 2020. The need to carry over water is lessened in wetter scenarios, because high reservoir inflows increase the likelihood of high water allocation at the start of 2020–21. This means that instead of carrying over water into the next season, it can be used to contribute to environmental watering events planned for 2019–20.

The highest-priority watering actions in 2019–20 aim to sustain the growth, flowering and seed development of emergent and bank vegetation. The long duration of high IVT flows in consecutive summers (2017–18 and 2018–19) means that lower bank and fringing vegetation has been under water for much of the past two years, severely affecting the health of plants and the condition of the banks.

Under drought conditions, the highest-priority watering actions are to deliver low flows throughout the year and a winter fresh in 2019. Under below-average conditions, all watering actions including low flows, winter and spring freshes and recession flow management are a high priority. However, in a below-average scenario, the magnitude and duration of the winter 2020 fresh may need to be reduced, and there may be less opportunity to build on naturally occurring events. Under average and wet conditions, the full suite of watering actions is recommended, although in a wet scenario unregulated flows (rather than managed flows) would provide the spring fresh and part of the winter 2020 fresh.

All environmental watering actions in Table 5.4.2 (apart from the autumn fresh) are a high priority for the Goulburn system. Delivering these actions in full would increase the likelihood that the functional watering objectives in Table 5.4.1 would be achieved. The key factor separating tier 1a and tier 1b actions is the anticipated supply of water for the environment for 2019–20. Under drought to below-average scenarios, it is expected that actions like the spring 2019 fresh (drought) or winter 2020 fresh (dry and below-average scenarios) cannot be delivered in full, so they are in tier 1b. The autumn 2019 fresh is a lower-priority action (i.e. tier 2) that may be implemented if more water becomes available than is needed to achieve all the tier 1 objectives and if various triggers are met over the summer period.

In some previous years, deliveries of water for the environment focused on supporting native fish spawning and migration. Flows to trigger fish spawning or migration are not specifically planned for 2019–20 for two reasons: to enable vegetation that has been under water for long durations due to IVT deliveries to establish and grow along the banks, and because these flows do not need to be delivered annually to maintain golden perch populations, because they are a long-lived species.

The recommended year-round low flows below Goulburn Weir (reaches 4 and 5) will maintain fish habitat and facilitate fish passage. These low flows will also help the growth of aquatic and amphibious vegetation and provide habitat and food for waterbugs and small-bodied fish by submerging snags and encouraging plankton production.

Table 5.4.2 Potential environmental watering for the Goulburn River under a range of planning scenarios

Planning scenario	Drought	Dry	Below average	Average	Wet
Expected river conditions	• No unregulated flows • Blackwater could be an issue in the warmer months	• Unregulated flows are expected to provide some low flows for half a month from winter to mid-spring and are likely to provide small, short winter/ spring freshes • Blackwater could be an issue in the warmer months	• Unregulated flows are expected to provide some low flows for a few months from winter to mid-spring and are likely to provide winter/ spring freshes • Blackwater could be an issue in the warmer months	• Unregulated flows are expected to provide low flows for most of the year and are likely to provide medium winter/ spring freshes • Blackwater could be an issue in the warmer months	• Unregulated flows are expected to provide low flows and multiple overbank flows events in winter/spring
Normal minimum passing flows at reach 5 of 400 ML/day during July to October and 350 ML/day during November to June					
Expected availability of water for the environment[1]	• 250,000 ML	• 344,000 ML	• 483,000 ML	• 516,000 ML	
Potential environmental watering – tier 1a (high priorities)	• Year-round low flows • Winter/spring variable low flows • Spring/autumn/ winter low flows (reach 1) • Winter 2019 fresh	• Year-round low flows • Winter/spring variable low flows • Spring/autumn/ winter low flows (reach 1) • Winter 2019 fresh • Spring fresh (partial)	• Year-round low flows • Winter/spring variable low flows • Spring/autumn/ winter low flows (reach 1) • Winter 2019 fresh • Spring fresh • Winter 2020 fresh (partial) • Recession flow management	• Year-round low flows • Winter/spring variable low flows • Spring/autumn/ winter low flows (reach 1) • Winter 2019 fresh • Spring fresh • Winter 2020 fresh • Recession flow management	• Year-round low flows • Winter/spring variable low flows • Spring/autumn/ winter low flows (reach 1) • Winter 2019 fresh • Winter 2020 fresh (partial) • Recession flow management
Potential environmental watering – tier 1b (high priorities)	• Spring fresh (partial) • Recession flow management	• Winter 2020 fresh (full) • Recession flow management	• Winter 2020 fresh (full)	• N/A	• N/A

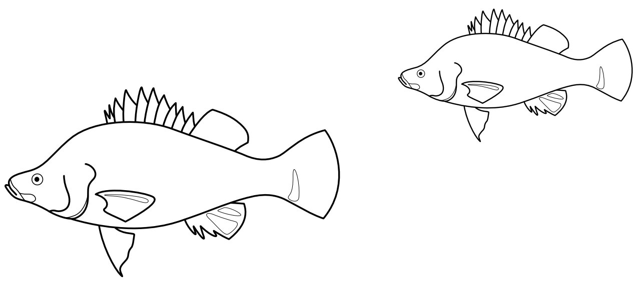
Table 5.4.2 Potential environmental watering for the Goulburn River under a range of planning scenarios *continued...*

Planning scenario	Drought	Dry	Below average	Average	Wet
Potential environmental watering – tier 2 (additional priorities)	• N/A	• N/A	• N/A	• Autumn fresh (partial) *Note:* triggers must be met before this flow is considered	• Autumn fresh *Note:* triggers must be met before this flow is considered
Possible volume of water for the environment required to achieve objectives[2]	• 214,000 ML (tier 1a) • 104,000 ML (tier 1b)	• 298,000 ML (tier 1a) • 150,000 (tier 1b)	• 434,000 ML (tier 1a) • 130,000 ML (tier 1b)	• 472,000 ML (tier 1a) • 20,000 ML (tier 2)	• 316,000 ML (tier 1a) • 47,000 ML (tier 2)
Priority carryover requirements	• 23,000 ML[3]	• 23,000 ML	• 23,000 ML	• 0 ML	• 0 ML

1 *When trading opportunities are available, additional water for the environment allocations from the Murray can be transferred in to meet Goulburn demand.*

2 *Water for the environment requirements for tier 2 actions are additional to tier 1 requirements.*

3 *Additional water is required to meet this priority carryover requirement under an extreme dry scenario.*



5.4.2 Goulburn wetlands

System overview

Of some 2,000 natural wetlands in the Goulburn Broken area, only three — Reedy Swamp, Gaynor Swamp and Doctors Swamp — have received water for the environment through VEWH or CEWH entitlements. Several other small wetlands in the Goulburn catchment have been watered under a separate arrangement through the Murray-Darling Wetlands Working Group. Recent modifications to the irrigation supply network and other water delivery options will enable water for the environment to be delivered to Loch Garry, Kanyapella Basin and Horseshoe Lagoon from 2019–20 onwards. These wetlands have strong cultural significance to the Yorta Yorta and Taungurung Traditional Owners.

Gaynor Swamp, Reedy Swamp, Loch Garry, Doctors Swamp and Kanyapella Basin wetlands can all receive water for the environment via irrigation supply infrastructure in the Shepparton and Central Goulburn irrigation districts. The volume of water that can be delivered to each wetland depends on the available capacity in the irrigation supply network, which varies with irrigation demand. Water for the environment will be delivered from the Goulburn River to Horseshoe Lagoon via a temporary pump.

Environmental values

Many natural wetlands across the Goulburn catchment including Reedy Swamp, Loch Garry, Gaynor Swamp, Kanyapella Basin and Doctors Swamp are formally recognised for their conservation significance. The Goulburn wetlands support a variety of plant communities ranging from river red gum swamps to treeless cane grass wetlands.

Reedy Swamp contains a mosaic of vegetation types including tall marsh, floodway pond herbland and rushy riverine swamp. It is an important drought refuge and nesting site for colonial waterbirds and an important stopover feeding site for migratory birds (such as sharp-tailed sandpiper and marsh sandpiper).

Doctors Swamp is considered one of the most-intact red gum swamps in Victoria, supporting over 80 wetland plant species.

Gaynor Swamp is a cane grass wetland situated on paleosaline soils – soils formed from historic oceans. The wetland supports thousands of waterbirds including brolga and intermediate egrets when wet. Gaynor Swamp has a higher salt concentration than other wetlands in the region, and it attracts a different suite of feeding waterbirds as it draws down. One of the most significant species that feed on exposed mudflats at Gaynor Swamp is the red-necked avocet.

Loch Garry supports large areas of deep, open water fringed by giant rush and dominated by tall marsh. It is an important site for waterbird feeding and roosting and is a drought refuge for eastern great egrets, musk ducks, nankeen night herons and royal spoonbills.

Kanyapella Basin is a shallow freshwater marsh that provides habitat for numerous plant and animal species including the threatened intermediate egret. It has historically been a popular site for ibis, heron and cormorants.

Horseshoe Lagoon, a former channel of the Goulburn River, comprises vegetation mainly of tall marsh, floodway pond herbland and floodplain riparian woodland.

Environmental objectives in the Goulburn wetlands

Maintain or increase the diversity and abundance of frog species
Maintain the population of turtles
Increase the diversity of native wetland plants consistent with the EVC[1] benchmarks Reduce the cover and diversity of exotic plants Maintain the population of rigid water milfoil
Provide breeding habitat for waterbirds Provide feeding and roosting habitat for waterbirds
Aboriginal environmental outcomes
Watering is planned to be delivered in partnership with Traditional Owners and achieve Aboriginal environmental outcomes

1 *Ecological vegetation classes (EVCs) are the standard unit for classifying vegetation types in Victoria. EVCs are described through a combination of floristics, lifeforms and ecological characteristics, and through an inferred fidelity to particular environmental attributes. Each EVC includes a collection of floristic communities (that is, lower level in the classification) that occur across a biogeographic range, and although differing in species, have similar habitat and ecological processes operating.*

Recent conditions

The Goulburn system experienced dry conditions and some of its highest temperatures on record during 2018–19.

Water for the environment was delivered to Reedy Swamp in spring 2018, to provide refuge for thousands of bird species including the threatened white-bellied sea eagle and glossy ibis. The wetland was allowed to draw down and dry over summer.

Gaynor Swamp received water for the environment for the first time in April 2018 and quickly became a feeding site for thousands of waterbirds including brolga. Observations of breeding behaviour in whiskered terns and brolga led to a subsequent top-up delivery in spring 2018, to support waterbird breeding.

Doctors Swamp was not actively watered during 2018–19, to allow it to dry and reduce exotic aquatic vegetation at the site.

Horseshoe Lagoon partially filled in December 2017 from natural flows in the Goulburn River, but the wetland, along with Kanyapella Basin, has not been fully inundated since 2011–12, and both are currently dry. Loch Garry was partially filled during natural floods in 2016 and dried in January 2019.

Scope of environmental watering

Table 5.4.3 describes the potential environmental watering actions that may be delivered in 2019–20, their functional watering objectives (that is, the intended physical or biological effect of the watering action) and the longer-term environmental objective they support. Each environmental objective relies on one or more potential environmental watering actions and their associated physical or biological functions.

Table 5.4.3 Potential environmental watering actions and objectives for the Goulburn wetlands

Potential environmental watering action	Functional watering objective	Environmental objective
Doctors Swamp (fill in autumn)	• Promote vegetation growth • Provide habitat for waterbird roosting and feeding	
Horseshoe Lagoon (fill in winter)	• Maintain wetland vegetation by supporting growth and recruitment • Promote the growth of river swamp wallaby-grass • Provide habitat for turtle and frog populations	
Kanyapella Basin (partial fill in spring or autumn)	• Promote different vegetation communities to establish	
Loch Garry (partial fill in autumn)	• Increase wetland vegetation growth and recruitment • Provide feeding/breeding habitat for a range of waterbirds	
Reedy Swamp (fill in autumn)	• Limit the growth of aquatic weeds by keeping the wetland dry in summer • Promote the growth of native wetland vegetation • Provide refuge and food/habitat for waterbirds	
Wetland drying		
Gaynor Swamp	• Reduce the extent of typha	

Scenario planning

Table 5.4.4 outlines the potential environmental watering and expected water use under a range of planning scenarios.

Goulburn Broken CMA has planned wetland watering to maintain a range of habitat types to support waterbirds and other water-dependent animals in the region at any point in time.

Doctors Swamp, Reedy Swamp and Horseshoe Lagoon have been identified as high-priority watering sites in 2019–20 under all climatic scenarios. If there are no natural flows, Doctors Swamp and Reedy Swamp will require water in autumn 2020 to maintain their existing wetland vegetation and to encourage recruitment. Horseshoe Lagoon has not received water for the environment before, and the interval since its last natural fill is threatening the condition of native plant communities. Water for the environment delivered to Horseshoe Lagoon in winter will aim to improve the condition of native wetland vegetation communities and provide habitat for native animals.

It is expected that sufficient water will be available to meet all priority watering actions, and hence no tier 1b actions are noted.

Loch Garry and Kanyapella Basin have been identified as tier 2 priorities for 2019–20. If the desired drying period (6–18 months) is met at Loch Garry, water may be delivered in autumn 2020. However, if the water is not available in 2019–20 and the wetland remains dry, the vegetation communities are likely to tolerate another year without water. Bathymetric survey work needs to be completed at Kanyapella Basin, to enable appropriate delivery volume estimates before a potential partial trial filling could be delivered in spring 2019 or autumn 2020.

Gaynor Swamp received water for the environment for the first time in autumn 2018 and an additional top-up in late spring/early summer 2018. The wetland will not be actively watered in 2019–20 and will be allowed to dry. The dry phase will reduce the extent of exotic weeds.

Table 5.4.4 Potential environmental watering for the Goulburn wetlands under a range of planning scenarios

Planning scenario	Drought	Dry	Average	Wet
Expected river conditions	• Catchment run off and unregulated flows into the wetlands are highly unlikely	• Catchment run off and unregulated flows into the wetlands are unlikely	• Some catchment run off and unregulated flow into some of the wetlands are likely, particularly in winter/spring	• Catchment run off and unregulated flow into the wetlands may significantly contribute to their water levels, particularly in winter/spring
Potential environmental watering – tier 1a (high priorities)	• Doctors Swamp • Horseshoe Lagoon • Reedy Swamp	• Doctors Swamp • Horseshoe Lagoon • Reedy Swamp	• Doctors Swamp • Horseshoe Lagoon • Reedy Swamp	• Doctors Swamp • Horseshoe Lagoon • Reedy Swamp
Potential environmental watering – tier 2 (additional priorities)	• Kanyapella Basin • Loch Garry	• Kanyapella Basin • Loch Garry	• Kanyapella Basin • Loch Garry	• Kanyapella Basin • Loch Garry
Possible volume of water for the environment required to achieve objectives[1]	• 1,300 ML (tier 1) • 1,000 ML (tier 2)	• 1,300 ML (tier 1) • 1,000 ML (tier 2)	• 1,000 ML (tier 1) • 1,000 ML (tier 2)	• 700 ML (tier 1) • 1,000 ML (tier 2)

[1] *Water for the environment requirements for tier 2 actions are additional to tier 1 requirements.*

5.5 Broken system

The Broken system includes the Broken River, upper Broken Creek, lower Broken Creek and various wetlands.

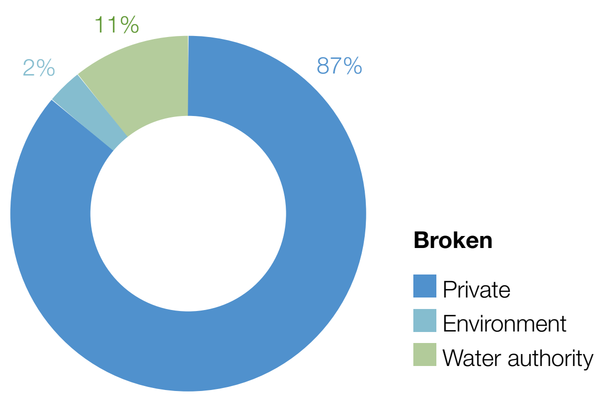
Waterway manager – Goulburn Broken Catchment Management Authority

Storage manager – Goulburn-Murray Water

Environmental water holders – Victorian Environmental Water Holder, Commonwealth Environmental Water Holder

Did you know ...?

Recent fish monitoring in sections of the Broken River and Broken Creek for the Victorian Environmental Flows Monitoring and Assessment Program shows that Murray cod of all ages, golden perch, Murray river rainbow fish and silver perch are all benefiting from environmental flows.



Proportion of water entitlements in the Broken basin held by private users, water corporations or environmental water holders at 30 June 2018.

Top: Lower Broken Creek, by Goulburn Broken CMA
Centre: Graeme Hackett, ARI, with a tagged Murray cod at Broken River, by Goulburn Broken CMA
Above: Common spadefoot toad at Moodie Swamp, by Jo Wood

5.5.1 Broken River and upper Broken Creek

System overview

The Broken River is a tributary of the Goulburn River, rising in the Wellington–Tolmie highlands and flowing north-west to Benalla and then west for a total distance of 190 km before it joins the Goulburn River near Shepparton. Lake Nillahcootie is the main storage on the Broken River. It is about 36 km upstream of Benalla and diverts water from the river to support stock and domestic supply and irrigated agriculture. The main tributaries of the Broken River are Hollands Creek, Ryans Creek and Lima East Creek.

Lake Nillahcootie has a storage capacity that is about half the mean annual flow of its upstream catchment, so it fills in most years. The operation of Lake Nillachootie has modified the river's natural flow pattern; winter/spring flows are less than natural because a large proportion of inflows are harvested, while summer/autumn flows are higher than natural because water is released to meet downstream irrigation demands. These impacts are most pronounced in the reach between Lake Nillahcootie and Hollands Creek. Downstream of Hollands Creek, the river retains a more-natural flow pattern due to the contribution of tributary inflows. The catchment has been extensively cleared for agriculture including dryland farming (such as livestock grazing and cereal cropping) and irrigated agriculture (such as dairy, fruit and livestock).

Water is released from Lake Nillahcootie to meet downstream demand and minimum-flow requirements specified under the bulk entitlement for the Broken River system. Releases from storage may be less than 30 ML per day as tributary inflows immediately below the storage (such as from Back Creek) can supply much of minimum-flow requirements specified in the bulk entitlement.

The upper Broken Creek is defined as the 89-km stretch of creek from the Broken River (at Caseys Weir) to the confluence with Boosey Creek near Katamatite. The upper Broken Creek flows across a flat, riverine plain and has naturally low run off from its local catchment. It receives flood flows from the Broken River, although the frequency of these floods has been reduced by earthworks and road construction.

Upper Broken Creek has been regulated for more than a century. Before 2007, water was diverted into upper Broken Creek at Casey's Weir to meet local demand, but recent water-savings projects have reduced the demand on the creek. There are now low flows throughout the year between Caseys Weir and Waggarandall Weir. Flows downstream of Waggarandall Weir are mainly influenced by rainfall and catchment run off. These changes have reduced the amount of permanent aquatic habitat.

Delivery of water for the environment to the Broken River is primarily constrained by the availability of water. Usually, the available volume of water for the environment is well short of the volume required to deliver the desired flow components. Deliveries of water for the environment to the upper Broken Creek are also restricted by channel capacity and by the need to avoid flooding low-lying adjacent land.

Environmental values

The Broken River retains one of the best examples of healthy in-stream vegetation in a lowland river in the region. A range of native submerged and emergent plant species including eelgrass, common reed and water ribbons populate the bed and margins of the river. These plants provide habitat for a range of animals including small- and large-bodied native fish species. Murray cod, Macquarie perch, golden perch, silver perch, river blackfish, mountain galaxias and Murray-Darling rainbowfish all occur in the Broken River. The river also supports a large platypus population.

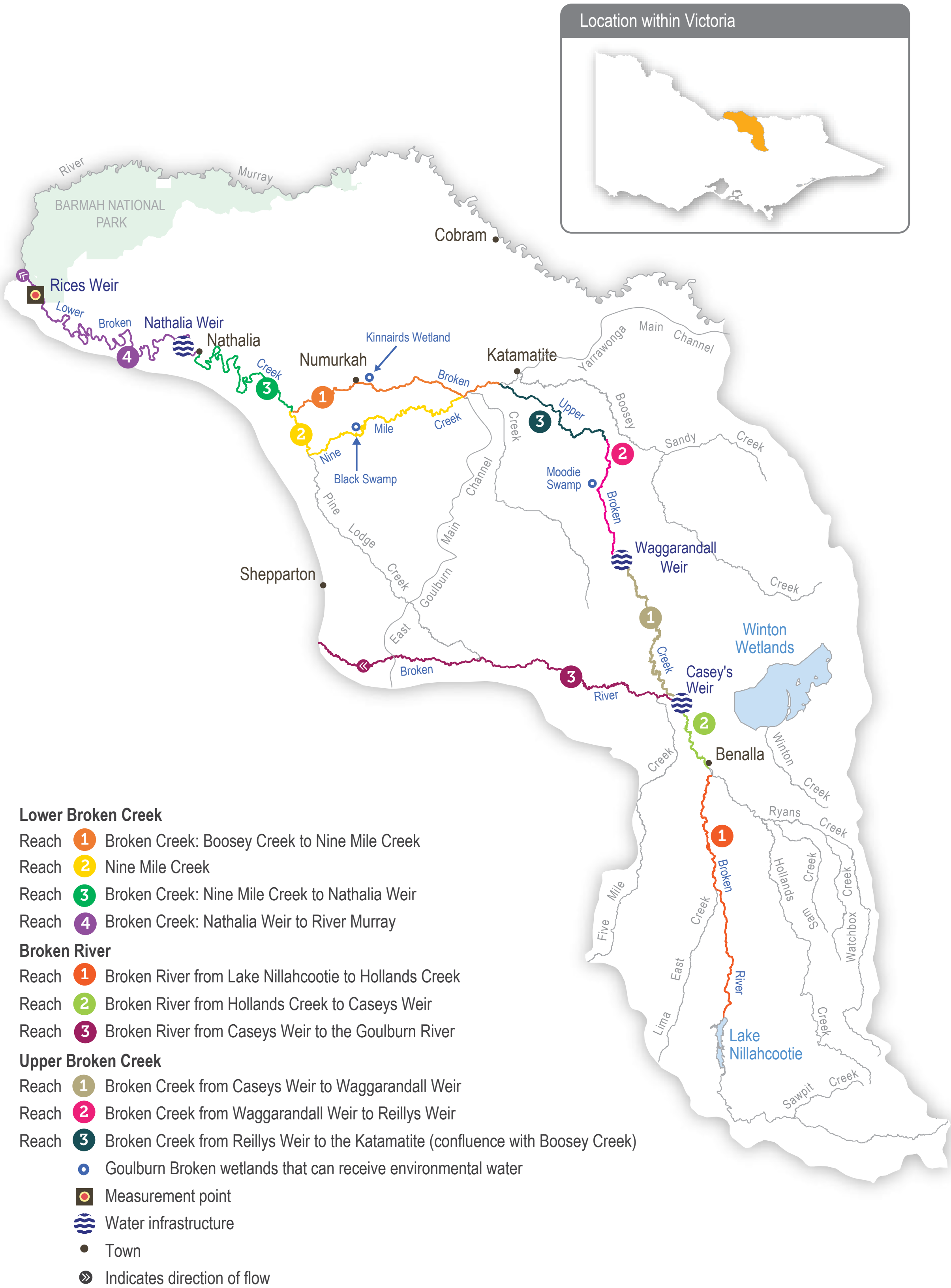
The upper Broken Creek area is dominated by unique box riparian vegetation and remnant plains grassy woodland. It supports numerous threatened species including brolga, Australasian bittern, buloke and rigid water milfoil. Much of the high-quality native vegetation in the region is set aside as a natural features reserve. Upper Broken Creek supports a variety of native fish species including carp gudgeon, Murray cod, golden perch and Murray-Darling rainbowfish, as well as platypus and common long-necked turtle.

Both the Broken River and upper Broken Creek are listed in the *Directory of Important Wetlands in Australia*.

Environmental objectives in the Broken River and upper Broken Creek

Increase native fish populations
Maintain platypus populations
Maintain in-stream vegetation
Support a wide range and high biomass of waterbugs, to break down dead organic matter and support the river's food web
Maintain water quality

Figure 5.5.1 The Broken system



Grey river reaches have been included for context. The numbered reaches indicate where relevant environmental flow studies have been undertaken. Coloured reaches can receive environmental water.

Recent conditions

Dry conditions were the dominant feature of flows in the Broken River and upper Broken Creek in 2018–19. Isolated rainfall events between August and December 2018 delivered a few small, natural freshes in the Broken River downstream of Lake Nillahcootie, which benefitted native fish and in-stream vegetation. Winter/spring flows in the upper Broken Creek were below minimum-flow requirements for most of the time, although two small, natural freshes helped maintain water quality and broad environmental values.

Environmental flows commenced in May 2019, to help maintain minimum-flow levels in the Broken River under ongoing dry conditions. These flows aim to maintain habitat and prevent the loss of aquatic vegetation, waterbugs and native fish leading into winter 2019.

Scope of environmental watering

Table 5.5.1 describes the potential environmental watering actions that may be delivered in 2019–20, their functional watering objectives (that is, the intended physical or biological effect of the watering action) and the longer-term environmental objective they support. Each environmental objective relies on one or more potential environmental watering actions and their associated physical or biological functions.

Table 5.5.1 Potential environmental watering actions and objectives for the Broken River and upper Broken Creek

Potential environmental watering action	Functional watering objective	Environmental objective
Summer/autumn fresh in upper Broken Creek (one fresh of up to 100 ML/day for 10 days during December to May)	• Maintain water quality, particularly dissolved oxygen levels, in refuge pools	
Summer/autumn low flows in upper Broken Creek (up to 10 ML/day for 30–60 days during December to May)	• Maintain pool and riffle habitat for native fish populations and waterbugs • Maintain access to habitat and food resources for platypus • Maintain habitat for in-stream vegetation	
Winter/spring low flows in upper Broken Creek (up to 15 ML/day for 30–60 days during June to November)	• Maintain pool and riffle habitat for native fish populations and waterbugs • Maintain access to habitat and food resources for platypus • Maintain habitat for in-stream vegetation	
Year-round low flows in the Broken River (up to 30 ML/day for 40–100 days)	• Maintain riffles, slackwater and pools to provide diverse hydraulic habitat for native fish, aquatic plants, platypus and waterbugs • Maintain habitat for in-stream and fringing aquatic vegetation and prevent terrestrial vegetation colonising the stream bed	
Summer/autumn freshes in the Broken River (one fresh of 400–500 ML/day for two to five days during December to May)	• Scour sediment around large wood and turn over bed sediments to replenish biofilms and increase productivity • Provide flow cues to stimulate native fish breeding and migration • Provide flow to maintain in-stream and fringing aquatic vegetation • Maintain longitudinal connectivity for native fish passage	

Scenario planning

Table 5.5.2 outlines the potential environmental watering and expected water use under a range of planning scenarios.

Environmental flow requirements for the upper Broken Creek and Broken River are greater than the volume of water for the environment expected to be available in the Broken system. Natural catchment run off and operational deliveries including mandated passing flows are expected to meet some of the recommended environmental flow requirements for these systems. Water for the environment will be used where possible to meet the highest-priority flows that are not met from consumptive deliveries or natural flows.

Priority is given to upper Broken Creek watering actions in summer and autumn under all scenarios to maintain water quality, although this is more likely to be required under drought and dry conditions than average to wet conditions. Flow targets in upper Broken Creek are less likely to be met by catchment run off and managed releases than in the Broken River, and a lack of flow in the creek poses a significant risk to native fish, platypus and macroinvertebrate populations.

If additional water for the environment is available, tier 1b actions can be delivered if required. Low flows and water quality freshening flows are potential demands throughout the year under most scenarios.

Any remaining water for the environment may be used in the Broken River. Minimum baseflows are planned to be maintained under drought and dry conditions, if not met through irrigation releases or catchment run off. A summer/autumn fresh in the Broken River is an additional demand, noting this may be met by the delivery of inter-valley transfers from the Broken system to the Goulburn system under some scenarios.

Table 5.5.2 Potential environmental watering for the Broken River and upper Broken Creek under a range of planning scenarios

Planning scenario	Drought	Dry	Average	Wet
Expected river conditions	• No unregulated winter and spring flows in Broken River • No unregulated flows in upper Broken Creek • Minimal volume transferred to the Goulburn River • Low and cease-to-flow events in summer/autumn below Waggarandall Weir on upper Broken Creek	• Low unregulated flows and some freshes in Broken River • No unregulated flows in the Upper Broken Creek • Up to 1,500 ML of consumptive water delivered via the Broken River in summer/autumn	• High winter and spring flows in the Broken River • Some contribution of unregulated winter and spring flows and freshes in upper Broken Creek • Up to 1,500 ML of consumptive water delivered via the Broken River in summer/autumn	
Expected availability of water for the environment	• 0–267 ML	• 304 ML	• 534 ML	
Potential environmental watering – tier 1a (high priorities)	• Summer/autumn fresh in upper Broken Creek (partial)	• Summer/autumn fresh in upper Broken Creek (partial)	• Summer/autumn fresh in upper Broken Creek (partial)	• Summer/autumn fresh in upper Broken Creek (partial)
Potential environmental watering – tier 1b (high priorities with shortfall)	• Summer/autumn fresh in upper Broken Creek (remaining demand) • Summer/autumn low flows in upper Broken Creek • Winter/spring low flows in upper Broken Creek • Year-round low flows in the Broken River	• Summer/autumn fresh in upper Broken Creek (remaining demand) • Summer/autumn low flows in upper Broken Creek • Winter/spring low flows in upper Broken Creek • Year-round low flows in the Broken River	• Summer/autumn fresh in upper Broken Creek (remaining demand) • Summer/autumn low flows in upper Broken Creek • Winter/spring low flows in upper Broken Creek	• Summer/autumn fresh in upper Broken Creek (remaining demand)
Potential environmental watering – tier 2 (additional priorities)		• Summer/autumn fresh in Broken River	• Summer/autumn fresh in Broken River	
Possible volume of water for the environment required to achieve objectives[1]	• 267 ML (tier 1a) • Up to 4,000 ML (tier 1b)	• 304 ML (tier 1a) • Up to 2,500 ML (tier 1b) • Up to 5,800 ML (tier 2)	• 534 ML (tier 1a) • Up to 1,180 ML (tier 1b) • Up to 5,800 ML (tier 2)	• 534 ML (tier 1a) • Up to 1.000 ML (tier 1b)

1 *Water for the environment requirements for tier 2 actions are additional to tier 1 requirements.*

5.5.2 Lower Broken Creek

System overview

The lower Broken Creek system includes the section of Broken Creek that flows from the confluence of Boosey Creek near Katamatite to the River Murray, and Nine Mile Creek, which is an anabranch that leaves lower Broken Creek at the East Goulburn Main Channel and re-joins downstream of Numurkah.

Lower Broken and Nine Mile creeks have been regulated for over a century. Before regulation, the creeks would have had most of their flow in winter and spring and then contracted to isolated pools or dried out during summer and autumn. The adjacent floodplain would have also flooded regularly. The creeks now have numerous weirs that maintain a relatively constant flow from mid-August until mid-May to support irrigated agriculture. These modifications have changed the way native animals use the creek. Previously, native fish would have moved into the creek when it was flowing and returned to the River Murray as it dried. Both creeks now provide year-round habitat for native fish, and fish passage structures allow fish to move between weir pools. Water for the environment is used to support these permanent fish habitats, by providing flows to trigger fish movement and support fish passage, control water quality and flush azolla as necessary.

The lower Broken Creek is operated separately to the upper Broken Creek and the Broken River, because regulated water is delivered to the lower Broken Creek from the Goulburn and Murray systems via the irrigation channel network.

Water for the environment can be provided to the lower Broken Creek from the Goulburn system through the East Goulburn Main Channel and from the Murray system through the Yarrawonga Main Channel. Water is released into the lower Broken Creek from several irrigation area regulators along the length of the lower Broken Creek. The main priority for environmental watering in the lower Broken Creek system is to maintain minimum flows throughout the year. Particular attention is given to reaches 1 and 2 during the non-irrigation season, when flow can stop. The next priority is to deliver freshes in winter and spring to trigger fish movement and spawning, maintain water quality and manage azolla blooms in reaches 3 and 4. The measurement point for environmental flows in the lower Broken Creek is at Rices Weir.

Some of the environmental flow targets for the lower Broken Creek are partly or wholly met by operational water releases (inter-valley transfers [from the Goulburn to the Murray] or choke bypass flows [when bypassing the Barmah choke in the Murray]) that are delivered to meet downstream demands. These operational deliveries mainly occur during peak irrigation demand between spring and autumn. Water for the environment may be used to supplement these operational releases and to deliver recommended flow components that are not met by the operational releases.

Environmental values

The lower Broken Creek and Nine Mile Creek support a diverse and abundant native fish community including the threatened Murray cod, golden perch, silver perch, unspecked hardyhead and crimson-spotted rainbowfish (also known as the Murray-Darling rainbowfish). Sections of the lower Broken and Nine Mile creeks have been reserved as state park and natural feature reserves. The associated floodplain and wetland habitats support box-dominated grassy woodland communities and numerous species of state and national conservation significance including river swamp wallaby-grass and the Australasian bittern.

Environmental objectives in the lower Broken Creek

Protect and increase native fish populations including the threatened Murray cod, golden perch and silver perch
Protect platypus populations, particularly outside the irrigation season Protect rakali (water rat) populations, particularly outside the irrigation season
Protect turtle populations, particularly outside the irrigation season
Avoid the excessive build-up of azolla Maintain the cover and condition of native in-stream and littoral vegetation communities
Maintain the diversity and abundance of waterbug populations
Maintain dissolved oxygen levels suitable for aquatic animals

Recent conditions

The lower Broken Creek system experienced below-average rainfall, record high temperatures and little unregulated flow during 2018–19. Water for the environment was used in combination with operational water to maintain flow in the creek, where possible.

Lower Broken Creek had particularly low flow during June and July 2018, due to lower-than-average rainfall and maintenance works at Katandra Weir and surrounding irrigation areas. Goulburn-Murray Water was forced to close the fish ladders in lower Broken Creek for a number of weeks during this period, to maintain critical weir pool habitat.

The low winter flow led to a build-up of azolla downstream of Nathalia in July 2018. Six blockages were identified, where azolla blanketed whole sections of the creek. Water for the environment was used to deliver a fresh at the start of the irrigation season in August. The fresh peaked at 450 ML per day at Rices Weir and successfully flushed azolla and stimulated fish movement.

Flows between September and December 2018 varied from 206 ML per day to 332 ML per day and often failed to meet the minimum-flow target of 250 ML per day, which is what is needed to maintain adequate fish habitat.

A combination of water for the environment and operational water maintained dissolved oxygen levels in the lower Broken Creek through summer 2018–19. This was particularly important in the wake of record high temperatures in January 2019, which increased the risk of low dissolved-oxygen levels in the weir pools.

The environmental flow study for the lower Broken Creek was updated in 2019. The study improved the scientific rationale for the current environmental flow regime and developed new objectives and flow recommendations for the flowing reaches upstream of Nathalia. One of the main amendments is a recommendation for minimum flows in reaches 1 and 2 over the non-irrigation season, to provide critical habitat for aquatic animals and protect in-stream vegetation.

There is limited formal and ongoing monitoring of ecological conditions in the lower Broken Creek, but the Broken Environmental Water Advisory Group observed when it met in February 2018–19 that:

- lower Broken Creek is looking better than it has since the 1990s
- golden perch and large Murray cod are being caught, and fishing has improved
- a platypus was recently sighted in a permanent weir pool in the Nine Mile Creek at Wunghu.

The platypus sighting was verified by several fishers and community members and is the first sighting in the reach.

Scope of environmental watering

Table 5.5.3 describes the potential environmental watering actions that may be delivered in 2019–20, their functional watering objectives (that is, the intended physical or biological effect of the watering action) and the longer-term environmental objective they support. Each environmental objective relies on one or more potential environmental watering actions and their associated physical or biological functions.

The rakali (water rats) have been included as an environmental objective for the year-round low flows in 2019–20. According to the 2019 Lower Broken Creek Environmental Flows study, a flow management regime that supports the survival and recruitment of platypus should also favour rakali (water rats), given that both species consume macroinvertebrates, have similar requirements with respect to the timing of lactation and juvenile dispersal and are vulnerable to the same range of predators.

Table 5.5.3 Potential environmental watering actions and objectives for the lower Broken Creek

Potential environmental watering action	Functional watering objective	Environmental objective
Year-round low flows of up to 200 ML/day in reaches 3 and 4 and 100 ML/day in reaches 1 and 2[1]	• Provide native fish passage through fish ladders • Provide suitable foraging habitat for platypus and rakali (water rats), and support the movement of juvenile platypus and rakali • Provide habitat for turtles including protection from exposure to cold in winter • Provide flowing water habitat and avoid winter drawdown of weir pools for fish, vegetation, waterbugs, platypus and turtles • Limit suspended sediment and maintain suitable dissolved oxygen conditions	
Winter/spring/summer/autumn high flows (up to 300 ML/day in reaches 3 and 4 during July to May)	• Provide habitat for fish and support fish movement, spawning and recruitment • Flush and mobilise azolla and maintain oxygen levels in summer	
Winter/spring freshes (up to three freshes of 450 ML/day during July to October)	• Flush and mobilise azolla, if it blooms • Trigger fish migration and movement	

[1] *Primarily planned for the irrigation season between mid-August and mid-May, but it may be delivered year-round subject to supply constraints. Constraints may mean these flows may not be delivered in the non-irrigation season.*

Scenario planning

Table 5.5.4 outlines the potential environmental watering and expected water use under a range of planning scenarios.

Due to regulation of the lower Broken and Nine Mile creeks, which creates highly modified and relatively uniform conditions, environmental flow recommendations are relatively constant from year to year and independent of annual climatic conditions.

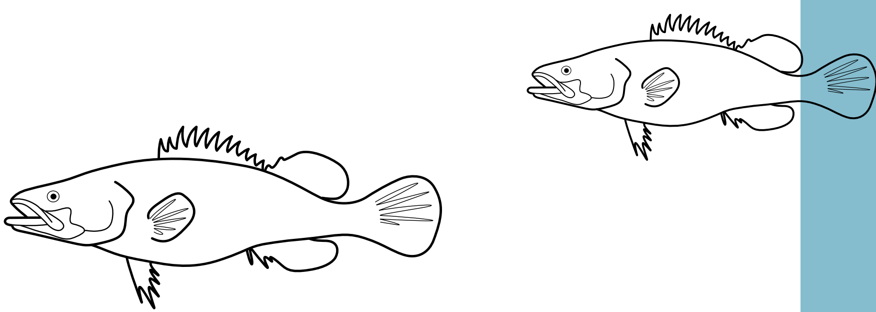
During 2019–20, environmental flows in the lower Broken Creek will be adjusted as needed to optimise the quantity of habitat and movement opportunities for native fish, maintain water quality and flush azolla through the system. The environmental flow objectives may be partly or wholly met by regulated flows to meet irrigation demand and by natural unregulated flows and therefore water for the environment will only be used to make up shortfalls. During dry conditions, water for the environment will be mainly used to deliver high flows and freshes, because irrigation demand and the associated operational water flows are likely to meet many of the environmental low-flow requirements. During wet conditions, there will be less demand for operational water, so more water for the environment may be needed to meet the low-flow requirements.

The potential environmental watering actions in Table 5.5.4 are all considered to be high priorities and are expected to meet the environmental requirements of the system. No second-tier priority watering actions have been identified for 2019–20.

In addition to the deliveries of water for the environment outlined in this seasonal watering plan, downstream demands (environmental or operational) may result in higher flows being delivered in the lower Broken Creek in 2019–20. Higher flows through the lower Broken Creek system generally provide positive environmental outcomes.

Table 5.5.4 Potential environmental watering for the lower Broken Creek under a range of planning scenarios

Planning scenario	Drought	Dry	Average	Wet
Expected river conditions	• No unregulated flows in winter • No flows throughout the irrigation season (mid-August to May) • No diversion of unregulated River Murray flows available	• Some unregulated flows in winter • No flows throughout the irrigation season (mid-August to May) • No diversion of unregulated River Murray flows available	• Unregulated flows in winter/spring • No unregulated flows during October to May (except for an occasional unregulated fresh in spring) • Diversion of unregulated River Murray flows available during mid-August to October	• Unregulated flows in winter/spring • No unregulated flows during November to May • Diversion of unregulated River Murray flows available during mid-August to November
Potential environmental watering (tier 1 – high priorities)	• Year-round low flows • Winter/spring/summer/autumn high flows • Winter/spring freshes			
Possible volume of water for the environment required to achieve objectives	• 56,500 ML	• 56,500 ML	• 54,500 ML	• 57,600 ML



5.5.3 Broken wetlands

System overview

Of some 2,000 natural wetlands in the Goulburn Broken area, only three in the Broken catchment have infrastructure that allow them to receive water for the environment: Black Swamp, Kinnairds Wetland and Moodie Swamp. Kinnairds Wetland and Black Swamp are red gum swamps near Numurkah. Moodie Swamp is a cane grass wetland adjacent to Broken Creek at Waggarandall that provides excellent breeding habitat for brolga.

The water regimes of these wetlands are influenced by their position in the landscape. The development and operation of the Shepparton, Central Goulburn and Murray Valley irrigation districts have changed the natural flow paths and the timing, frequency, volume and duration of natural flooding to these and other wetlands in the region. Existing irrigation system infrastructure enables water for the environment to be delivered to the three nominated wetlands, but irrigation deliveries have priority within the channel system. This limits the volume of water that can be delivered to the wetlands, often when it is most needed.

Environmental values

Moodie Swamp, Kinnairds Wetland and Black Swamp support a high diversity of vegetation communities ranging from river red gum-dominated swamps to cane grass wetlands. The wetlands contain state and nationally threatened vegetation communities and species including ridged water milfoil and river swamp wallaby-grass. The wetlands also provide food resources and breeding habitat for bird species of high conservation significance (such as eastern great egret, Latham's snipe, white-bellied sea eagle, Australasian bittern, brolga, royal spoonbill, yellow-billed spoonbill, Australasian shoveler and glossy ibis). Many of these species are listed in international agreements and conventions.

Environmental objectives in the Broken wetlands

	Provide breeding habitat for waterbirds Provide feeding and roosting habitat for waterbirds
	Increase the diversity of native wetland plants consistent with the EVC[1] benchmarks Reduce the cover and diversity of exotic plant species Increase and maintain populations of rigid water milfoil and slender water milfoil

1 *Ecological vegetation classes (EVCs) are the standard unit for classifying vegetation types in Victoria. EVCs are described through a combination of floristics, lifeforms and ecological characteristics, and through an inferred fidelity to particular environmental attributes. Each EVC includes a collection of floristic communities (that is, lower level in the classification) that occur across a biogeographic range, and although differing in species, have similar habitat and ecological processes operating.*

Recent conditions

The Broken River catchment received below-average rainfall and some of its highest recorded temperatures during 2018–19. Water for the environment was delivered to Black Swamp and Kinnairds Wetland in spring, to support the growth of native vegetation and provide refuge for birds and other water-dependent animals. Both wetlands responded with increased wetland plant cover including threatened species (such as river swamp wallaby-grass). Both wetlands dried over summer and autumn.

Moodie Swamp was allowed to dry during 2018–19, to reduce competition from exotic plants. Drying cycles are critical for supporting a healthy, productive wetland environment.

Scope of environmental watering

Table 5.5.5 describes the potential environmental watering actions that may be delivered in 2019–20, their functional watering objectives (that is, the intended physical or biological effect of the watering action) and the longer-term environmental objective they support. Each environmental objective relies on one or more potential environmental watering actions and their associated physical or biological functions.

Table 5.5.5 Potential environmental watering actions and objectives for the Broken wetlands

Potential environmental watering action	Functional watering objective	Environmental objective
Black Swamp (fill in autumn)	• Promote the growth of river swamp wallaby-grass • Provide waterbird habitat	
Kinnairds Wetland (fill in autumn)	• Promote the germination and growth of rigid and slender water milfoil • Prime the wetland for waterbird breeding	
Moodie Swamp (partial fill in autumn)	• Promote cane grass growth • Promote the germination and growth of rigid water milfoil • Provide habitat for brolga nesting	

Scenario planning

Table 5.5.6 outlines the potential environmental watering and expected water use under a range of planning scenarios.

Goulburn Broken CMA has undertaken landscape-scale planning for these wetlands to maintain a high diversity of habitat types in the region to support waterbirds and other water-dependent animals. Plans have been made under a range of climate scenarios to guide decision-making, but decisions to deliver water for the environment to the Broken wetlands will be based largely on their hydrological condition and observed waterbird breeding activity and on the potential impact of environmental watering on wetland vegetation communities.

Moodie Swamp has been identified as a high priority in all planning scenarios, as it remained dry throughout 2018–19. A partial fill in autumn will provide habitat for waterbirds and promote wetland vegetation growth for threatened and vulnerable species (such as rigid and slender milfoil).

It is expected that sufficient water will be available to meet all priority watering actions, so no tier 1b actions are noted.

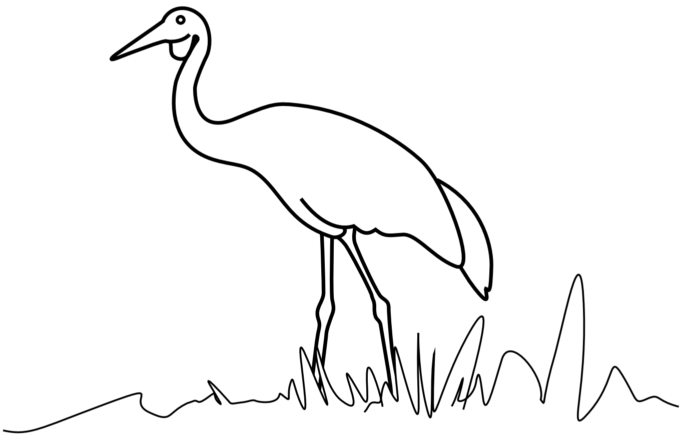
Black Swamp and Kinnairds Wetland are secondary priorities in all planning scenarios. Both wetlands received water for the environment in 2018–19, and their vegetation communities are likely to tolerate a year without additional water. Water for the environment may be used to fill these wetlands in autumn, if sufficient water resources are available. This would build on positive vegetation and waterbird responses to watering in 2018–19.

All three wetlands will be likely to fill naturally in winter or spring under a wet climate scenario. Small volumes of water for the environment may be required under these circumstances, to extend the duration or extent of natural flooding, helping to support a significant waterbird breeding event.

Table 5.5.6 Potential environmental watering for the Broken wetlands under a range of planning scenarios

Planning scenario	Drought	Dry	Average	Wet
Expected river conditions	• Catchment run off and unregulated flows into the wetlands are highly unlikely	• Catchment run off and unregulated flows into the wetlands is unlikely	• Some catchment run off and unregulated flows into some of the wetlands is likely, particularly in winter/spring	• Catchment run off and unregulated flows into the wetlands may significantly contribute to water levels in the wetlands, particularly in winter/spring
Potential environmental watering – tier 1a (high priorities)	• Moodie Swamp	• Moodie Swamp	• Moodie Swamp	• Moodie Swamp
Environmental watering – tier 2 (additional priorities)	• Black Swamp • Kinnairds Wetland	• Black Swamp • Kinnairds Wetland	• Black Swamp • Kinnairds Wetland	• Black Swamp • Kinnairds Wetland
Possible volume of water for the environment required to achieve objectives[1]	• 500 ML (tier 1) • 580 ML (tier 2)	• 500 ML (tier 1) • 580 ML (tier 2)	• 500 ML (tier 1) • 580 ML (tier 2)	• 500 ML (tier 1) • 580 ML (tier 2)

[1] *Water for the environment requirements for tier 2 actions are additional to tier 1 requirements.*



5.6 Campaspe system

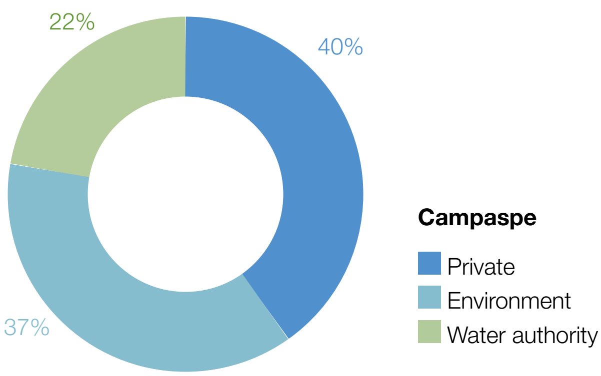
Waterway manager – North Central Catchment Management Authority

Storage manager – Goulburn-Murray Water, Coliban Water

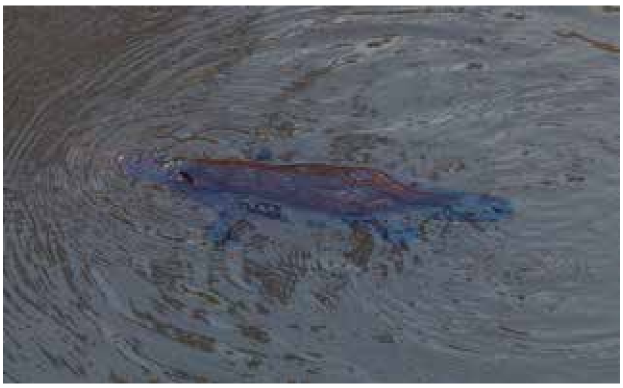
Environmental water holders – Victorian Environmental Water Holder (including the Living Murray program), Commonwealth Environmental Water Holder

Did you know ...?

The Campaspe River forms a boundary between Dja Dja Wurrung Country and Taungurung Country, and is known to both peoples as *Yerrin*. Taungurung also know the Campaspe River between Kyneton and Heathcote as *Boregam*.



Proportion of water entitlements in the Campapse basin held by private users, water corporations or environmental water holders at 30 June 2018.



Top: Coliban River, by North Central CMA
Centre: Recreation on the Campaspe River, by North Central CMA
Above: Platypus at English's Bridge, by Paula Markey

The Campaspe catchment extends from the Great Dividing Range in the south and outfalls to the River Murray in the north, a total distance of about 150 km. The Campaspe River is the main waterway in the catchment and flows through urban, peri-urban and rural town including Kyneton, Elmore, Rochester and Echuca. The second-largest waterway is the Coliban River, which also rises in the Great Dividing Range to the west of the Campaspe River before joining it at Lake Eppalock.

5.6.1 Campaspe River

System overview

Natural inflows in the upper Campaspe River catchment are harvested into Lake Eppalock, which is located near the townships of Axedale and Heathcote. The main tributaries of the Campaspe River are the Coliban River, McIvor and Pipers creeks upstream of Lake Eppalock and Mount Pleasant, Forest and Axe creeks downstream of Lake Eppalock. Below Lake Eppalock, the major in-stream structure is the Campaspe Weir, which was built to divert water to the Campaspe Irrigation District. It is no longer used for water diversion, but is a barrier to fish migration. Higher flows usually spill over the weir. The Campaspe Siphon, just downstream of Rochester, is part of the Waranga Western Channel, which carries water from the Goulburn system to western Victoria. Water can be released from the Waranga Western Channel into the lower reaches of the Campaspe River, but the siphon is another barrier to fish migration at low-to-moderate flows.

Flows downstream of Lake Eppalock are largely influenced by releases from storage and the operation of the Campaspe Weir and the Campaspe Siphon near Rochester. The Campaspe's major tributary — the Coliban River — flows through the three Coliban Water storages — the Upper Coliban, Lauriston and Malmsbury reservoirs — before reaching Lake Eppalock. Water for the environment is held and released from Lake Eppalock, with some limited ability to regulate flows further downstream at the Campaspe Weir.

Water for the environment is released from Lake Eppalock to support aquatic plants and animals in and along the river. It can be supplemented by water for the environment delivered via the Waranga Western Channel at the Campaspe Siphon, which provides important flexibility to meeting reach 4 demands. Water for the environment is primarily used to improve the magnitude and variability of flows during the winter and spring. Primary flow measurement points are at Barnadown (reach 2) and downstream of the Campaspe Siphon (reach 4).

Goulburn-Murray Water transfers operational water from Lake Eppalock to customers in the River Murray and to downstream storages (such as Lake Victoria). These inter-valley transfers (IVTs) usually occur in summer/autumn and can significantly increase flows in the Campaspe River at a time when flows would naturally be low. High IVT flows may reduce the amount of suitable habitat for juvenile fish, which rely on protected, shallow areas of water near the edge of the river channel. They can also drown streamside vegetation. Storage managers and the CMA have been working cooperatively to enhance the positive effects and limit any negative effects IVTs may have on native plants and animals. For example, IVTs have been released in a pattern to support native fish migration from the River Murray into reach 4 of the Campaspe River, without affecting delivery to downstream users.

Environmental values

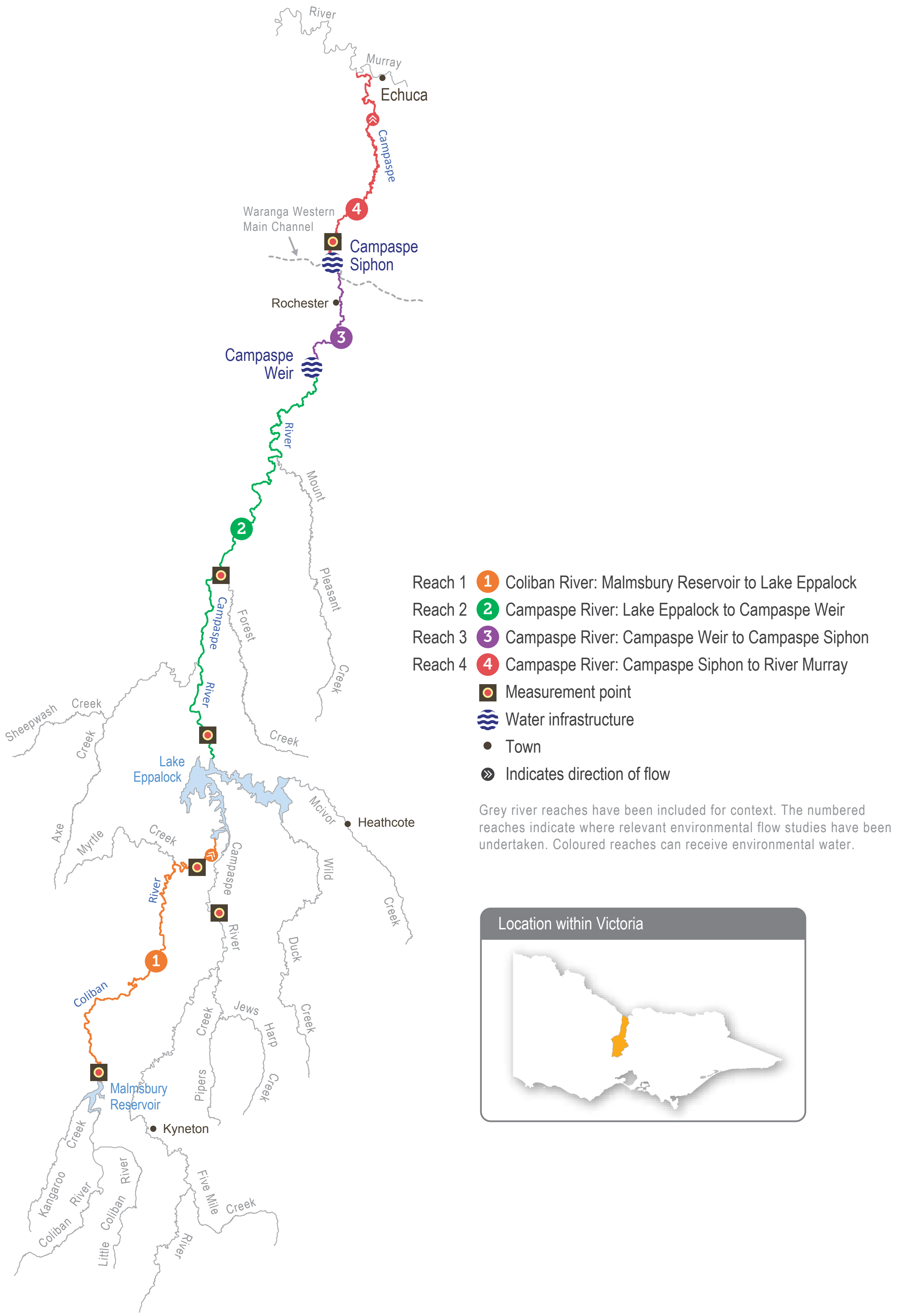
The Campaspe River downstream of Lake Eppalock provides important habitat for several native fish species including Murray cod, silver perch, golden perch, Murray-Darling rainbowfish and flat-headed gudgeon. Murray-Darling rainbowfish were presumed lost from the system during the Millennium Drought, but since 2011 they have been recorded at many sites on the Campaspe River and are now abundant downstream of Elmore. Maintaining flows is important for migration opportunities and dispersal of native fish species throughout the Campaspe system.

Platypus, rakali (water rats), turtles and frogs are also present along the length of the Campaspe River. The streamside vegetation zone is narrow and dominated by large, mature river red gum trees that support wildlife (such as the swift parrot and squirrel glider).

Environmental objectives in the Campaspe River

Provide habitat to help protect and increase populations of native fish
Maintain the resident platypus population by providing places to rest, breed and feed, as well as opportunities for juveniles to disperse
Maintain adult river red gums and provide opportunities for successful recruitment Maintain the extent and increase the diversity of riparian vegetation Increase the extent of in-stream aquatic plants
Increase waterbug productivity
Maintain water quality in deep pools and prevent stratification in summer Reduce the risk of blackwater events in summer

Figure 5.6.1 The Campaspe system



Recent conditions

The Campaspe system had below-average rainfall and above-average temperatures throughout 2018–19. January 2019 was especially hot across the system.

There were few unregulated flows from tributaries in 2018–19, and Lake Eppalock did not spill. The dry conditions led to high operational water demand in the Murray and Goulburn systems. Large volumes of IVTs were delivered from the Campaspe system to meet these demands; and despite few unregulated flows in the Campaspe River, the high operational flow meant that conditions were more like average in summer/autumn. The North Central CMA worked with ecologists to advise storage managers about minimising risks to environmental values throughout this period.

The Campaspe River received several planned environmental flows in 2018–19. Water for the environment was used to deliver winter low flows from 1 July 2018, with a small break (cease-to-flow) for three days in early August due to maintenance works at the Eppalock outlet tower. IVTs were delivered from mid-August to mid-September. A winter/spring high flow of 1,500 ML per day for six days commenced in mid-September, before resuming the low flow of 200 ML per day. The winter/spring high flow was delivered in September, to ensure low and stable flows during the critical Murray cod nesting period in October. IVTs resumed in late October and continued through summer and autumn. Water for the environment was used to deliver several summer/autumn freshes, to maintain water quality.

Monitoring of native fish and vegetation continued in the Campaspe River in 2018–19 as part of the Victorian Environmental Flows Monitoring Assessment Program (VEFMAP). Murray cod larvae were detected for the second year in a row, and eggs or larvae of Australian smelt, flat-headed gudgeon, carp gudgeon, redfin and carp were also detected. Very few young-of-year fish were caught in the surveys, which indicates a lack of recent recruitment. Rapid changes in river flows and lower water temperatures as a result of IVTs during the spawning period could be having an adverse affect on the survival and recruitment of young native fish.

Scope of environmental watering

Table 5.6.1 describes the potential environmental watering actions that may be delivered in 2019–20, their functional watering objectives (that is, the intended physical or biological effect of the watering action) and the longer-term environmental objective they support. Each environmental objective relies on one or more potential environmental watering actions and their associated physical or biological functions.

Table 5.6.1 Potential environmental watering actions and objectives for the Campaspe River

Potential environmental watering action	Functional watering objective	Environmental objective
Summer/autumn low flows (10–40 ML/day during December to May)	• Maintain backwater habitat for zooplankton and nursery habitat for native fish • Maintain habitat for native in-stream vegetation to colonise the channel margins • Promote the growth of biofilms to support macroinvertebrates and provide habitat for fish • Maintain the water quality and depth in deep pools in summer • Allow platypus to safely move between pools while foraging and ensure adequate food for lactating females	
Winter/spring low flows (up to 20–70 ML/day during June to November)	• Maintain pool and riffle habitat to support macroinvertebrate communities and feeding habitat for fish and platypus • Allow localised fish movement by maintaining adequate depth between pool habitat • Facilitate the long-distance movement of male platypus, especially in the August to October breeding season • Provide foraging opportunities across a wide range of habitats for female platypus to develop fat reserves before breeding • Maintain water quality by preventing pools stratifying	

Table 5.6.1 Potential environmental watering actions and objectives for the Campaspe River *continued...*

Potential environmental watering action	Functional watering objective	Environmental objective
Winter/spring freshes (up to two freshes of 1,000-1,500 ML/day for two to five days during June to November)	• Flush accumulated leaf litter from the bank and low benches, to reduce the risk of blackwater events during managed flow releases in summer • Maintain soil moisture for established river red gum and woody shrubs • Maintain connectivity to allow fish movement, which in turn allows them to optimise their habitat and perhaps breed • Encourage female platypus to select a nesting burrow higher up the bank to reduce the risk of high flow later in the year flooding the burrow when juveniles are present[1]	
Higher winter/spring low flows (50–200 ML/day during June to November)	• Maintain pool and riffle habitat to support macroinvertebrate communities and feeding habitat for fish and platypus • Allow localised fish movement by maintaining adequate depth between pools • Facilitate the long-distance movement by male platypus, especially in the August to October breeding season • Provide foraging opportunities across a wide range of habitat for female platypus to develop fat reserves before breeding • Maintain water quality by preventing pools stratifying • Prevent terrestrial plants colonising the lower sections of the riverbank and low benches in the channel • Maintain soil moisture in the riverbank for established river red gum and woody shrubs • Help establish littoral vegetation	
Summer/autumn freshes (three freshes of 100-200 ML/day for two to three days during December to May)	• Promote the local movement of adult fish, to access alternative habitat • Wet submerged wood and flush fine silt and old biofilms, to promote new biofilm growth and increase macroinvertebrate productivity • Facilitate the downstream dispersal of juvenile platypus in April and May to colonise other habitat areas • Inundate low bars, benches and low portions of the bank to maintain fringing and emergent vegetation	

[1] *Deliver before the platypus' egg-laying season, ideally in August.*

Scenario planning

Table 5.6.2 outlines the potential environmental watering and expected water use under a range of planning scenarios.

For 2019–20, the highest-priority flows that are expected to be met with supply of water for the environment are low flows and freshes throughout the year, represented as tier 1a actions in Table 5.6.2. This includes additional 'emergency' freshes that can be delivered in a low-dissolved-oxygen situation to avoid critical loss of habitat and species. In a drought scenario, the winter/spring low flow in tier 1a would be reduced, which would increase the risk of low water quality and would mean fewer opportunities for fish and platypus movement and foraging. Additional water in a drought scenario is needed to achieve important higher-magnitude winter/spring low flows (tier 1b) to increase opportunities for fish and platypus movement and foraging and to reduce the risk of low water quality.

If more water becomes available than that needed to meet tier 1 objectives, higher low flows, more freshes and potentially fish-attractant flows in summer (tier 2) could be delivered. Note however that the fish-attractant flows in summer are a low priority, because a lack of large-scale breeding in the River Murray last year has meant that there are likely to be few potential fish recruits.

Carryover into 2020–21 is not a priority this year, because sufficient allocation from a very high-reliability entitlement is expected to be available on 1 July 2020 to meet minimum critical demands.

Table 5.6.2 Potential environmental watering for the Campaspe River under a range of planning scenarios

Planning scenario	Drought	Dry	Average	Wet
Expected river conditions	• Few or no unregulated flows • High operational water deliveries • No passing flows in winter • No spills from storage	• Some unregulated flows • High operational water deliveries • Increased passing flows • No spills from storage	• Some unregulated flows • Increased passing flows	• Unregulated flows • Increased passing flows • Spills from storage
Expected availability of environmental water	• 17,000 ML	• 21,000 ML	• 36,400 ML	• 38,400 ML
Potential environmental watering – tier 1a (high priorities)	• Summer/autumn low flow • Winter/spring low flow (reduced) • Winter/spring fresh • One to three summer/autumn freshes • Additional freshes may be required to avoid critical loss of species/habitat if a low-dissolved-oxygen event occurs	• Summer/autumn low flow • Winter/spring low flow • Winter/spring fresh • One to three summer/autumn freshes • Additional freshes may be required to avoid critical loss of species/habitat if a low-dissolved-oxygen event occurs	• Summer/autumn low flow • Higher winter/spring low flow • Winter/spring fresh • One to three summer/autumn freshes • Additional freshes may be required to avoid critical loss of species/habitat if a low-dissolved-oxygen event occurs	• Summer/autumn low flow • Higher winter/spring low flow • Winter/spring fresh • One to three summer/autumn freshes • Additional freshes may be required to avoid critical loss of species/habitat if a low-dissolved-oxygen event occurs
Potential environmental watering – tier 1b (high priorities)	• Winter/spring low flow	• N/A	• N/A	• N/A
Potential environmental watering – tier 2 (additional priorities)	• Higher winter/spring low flow • Winter/spring fresh (one additional event) • Increased magnitude of summer/autumn freshes • Provide fish-attracting flows in summer	• Higher winter/spring low flow • Winter/spring fresh (one additional fresh) • Increased magnitude of summer/autumn freshes • Provide fish-attracting flows in summer	• Winter/spring fresh (one additional fresh) • Increased magnitude of freshes • Provide fish-attracting flows in summer	• Higher winter/spring low flow • Winter/spring fresh (one additional fresh) • Increased magnitude of freshes • Provide fish-attracting flows in summer
Possible volume of water for the environment required to achieve objectives[1]	• 14,700 ML (tier 1a) • 5,000 ML (tier 1b) • 9,700 ML (tier 2)	• 20,300 ML (tier 1) • 5,000 ML (tier 2)	• 26,700 ML (tier 1) • 6,900 ML (tier 2)	• 28,600 ML (tier 1) • 10,000 ML (tier 2)

[1] *Water for the environment requirements for tier 2 actions are additional to tier 1 requirements.*

5.6.2 Coliban River

The Coliban River is the major tributary of the Campaspe River and flows into Lake Eppalock. It is highly regulated with three storages harvesting water primarily for urban use.

Flows in the Coliban River downstream of Malmsbury Reservoir are regulated by the operation of the Malmsbury, Lauriston and Upper Coliban storages. An important distinction between the Coliban River and other regulated Victorian systems is the lack of irrigation demand. Therefore, flows in the river are influenced by the passing-flow entitlement, which depends on catchment inflows, transfers of water to Lake Eppalock and major flood events in the catchment.

Reach 1 of the Coliban River below Malmsbury Reservoir to Lake Eppalock can benefit from environmental watering. The VEWH does not have any environmental entitlements in the Coliban system, but passing flows can be managed — for example, they can be accumulated and released when most needed — to help mitigate some risks associated with critically low summer/autumn flows including low-dissolved-oxygen levels. A small volume of Commonwealth water for the environment is held in the system, but the high cost of delivery means there is no plan to use it in 2019–20.

Environmental values

The Coliban River provides important habitat for platypus, rakali (water rats) and small-bodied native fish (such as flat-headed gudgeon and mountain galaxias). The Coliban River also contains a diverse range of waterbugs supported by stands of emergent and submergent aquatic vegetation. It is bordered by remnant patches of stream bank shrubland vegetation and woodland containing river red gum, callistemon, woolly tea-tree and inland wirilda, which provide habitat for terrestrial animals.

Environmental objectives in the Coliban River

Increase the abundance and diversity of small-bodied native fish
Clean fine sediment from substrates to support biofilms
Increase platypus communities by providing opportunities for successful breeding and dispersal
Increase the cover and diversity of aquatic plants Increase the cover and diversity of fringing vegetation, while limiting encroachment into the middle of the channel
Maintain adequate diversity and biomass of waterbugs, to break down dead organic matter and support the river's food chain
Improve water quality and maintain healthy levels of dissolved oxygen in pools

Recent conditions

Rainfall in the Coliban River catchment during 2018–19 has been variable although generally below average. Rainfall between August and November is essential for filling the Coliban storages, and it was about 75 percent of the long-term average in 2018. For most of the year, there were little to no unregulated flows from catchment run off, so flows in the Coliban River were generally well-below minimum environmental flow recommendations.

Passing flows from Malmsbury Reservoir were reduced from up to 8 ML per day to 4 ML per day during winter/spring, to build a reserve that could maintain continuous flows through parts of the Coliban River over summer. Without this action, most of the Coliban River would have likely stopped flowing in summer. Even with the release of these accumulated passing flows, the lowest reaches of the Coliban River contracted to a series of isolated pools in March 2019.

Accumulated passing flows were used to deliver a summer/autumn fresh of 50 ML per day for three days from Malmsbury Reservoir in early March 2019, to support fish and platypus movement, maintain aquatic and fringing vegetation, improve water quality and waterbug habitat and flush organic material and sediment from in-stream substrates. The timing of this fresh was amended to align with a Dja Dja Wurrung field trip for a series of Aboriginal waterways assessments. Dja Dja Wurrung representatives were able to witness the progress of the fresh through the system and observe the transition from a series of disconnected pools into a flowing river.

Scope of environmental watering

Table 5.6.3 describes the potential environmental watering actions that may be delivered in 2019–20, their functional watering objectives (that is, the intended physical or biological effect of the watering action) and the longer-term environmental objective they support. Each environmental objective relies on one or more potential environmental watering actions and their associated physical or biological functions.

Table 5.6.3 Potential environmental watering actions and objectives for the Coliban system

Potential environmental watering action	Functional watering objective	Environmental objective
Pulsed summer/autumn low flow (5–15 ML/day for up to two weeks during December to May as required)	• Maintain water quality including dissolved oxygen levels • Maintain refuge habitat for aquatic animals including fish and platypus	
Summer/autumn low flow (1–10 ML/day during December to May)	• Maintain aquatic habitat that can support waterbugs, native fish, platypus and aquatic and fringing vegetation • Maintain water quality including dissolved oxygen levels	
Summer/autumn freshes (two freshes of up to 160 ML/day for up to three days during December to May)[1]	• Maintain the water depth through riffle-run habitats of 5–20 cm for a 25–50 ML/day event to maintain water quality and habitat for waterbugs • Maintain the water depth through riffle-run habitats of 45–55 cm for a 160 ML/day event to: • increase the water depth to facilitate fish and platypus movement • clean river substrates • inundate the low benches to support the fringing vegetation • clear sediment and biofilms from hard substrates in the bottom of the channel	

[1] *Summer freshes should be delivered once the 2020–21 critical water reserves have been provided.*

Scenario planning

Table 5.6.4 outlines the potential environmental watering and expected water use under a range of planning scenarios. Watering actions have only been considered for drought to average scenarios, because under a wet scenario the storages are likely to spill and therefore it will not be possible to accumulate passing flows. There is insufficient water available to meet all the requirements for water for the environment of the Coliban system, and managers must prioritise actions annually.

Under drought conditions, the priority will be to provide pulsed or continuous low flows for as long as possible in summer and autumn, to maintain aquatic habitat and water quality for as much of the reach downstream of Malmsbury Reservoir as possible. Under dry and average conditions, it should be possible to provide low flows for longer periods. Water is not likely to be available to provide summer/autumn freshes, except under average conditions or when a sufficient volume has been carried over and has not been lost to spill. The target flows and duration of freshes to mitigate a potentially catastrophic water quality incident will vary depending on water availability, the severity of the conditions and the incident, and the amount of flow and water in the river at the time.

The tier 1a watering actions will not prevent cease-to-flow events in the lower sections of the Coliban River during a hot and dry summer. Such conditions represent a risk to native plant, fish and platypus populations. Any additional water that becomes available under a drought scenario should be carried over to help deliver critical low flows in summer/autumn 2020–21, but under other scenarios it may be used to increase the magnitude of low flows or provide additional freshes in summer/autumn 2019–20.

Table 5.6.4 Potential environmental watering for the Coliban River under a range of planning scenarios

Planning scenario	Drought	Dry	Average
Expected river conditions	• Little or no unregulated flows	• Some unregulated flows from tributary inflows	• Some unregulated river flows from tributary inflows
Expected availability of water for the environment	• Minimal passing flows and low volume to withhold for use at other times in the season	• Slightly increased passing flows	• Moderate-to-high passing flows but reduced ability to reserve flows due to possible storage spills • Withheld flows for use at other times in the season
Potential environmental watering – tier 1a (high priorities – expected to be delivered in 2019–20)	• Pulsed or continuous summer/autumn low flows	• Summer/autumn low flows • Summer/autumn freshes	
Potential environmental watering – tier 1b (reliant on additional water becoming available in 2019–20)	• Set aside reserve for critical needs in 2020–21	• N/A	
Potential environmental watering – tier 2 (additional priorities)[1]	• Increased magnitude of summer/autumn low flows • Provide summer/autumn freshes	• Increased magnitude of summer/autumn low flows • Provide additional summer/ autumn freshes	• Increased magnitude of summer/autumn low flows • Increased magnitude of summer freshes
Possible volume of water for the environment required to achieve objectives[2]	• 1,200 ML (tier 1a) • 720 ML (tier 1b) • Tier 2 – dependent on water resources and river conditions	• 1,600 ML (tier 1a) • Tier 2 – dependent on water resources and river conditions	• 2,200 ML (tier 1a) • Tier 2 – dependent on water resources and river conditions
Priority carryover requirements	• Reserve passing flows for 2020–21		

1 *Only a priority after 2019–20 critical carryover requirements have been set aside.*

2 *Water for the environment requirements for tier 2 actions are additional to tier 1 requirements.*

5.7 Loddon system

Waterway manager – North Central Catchment Management Authority

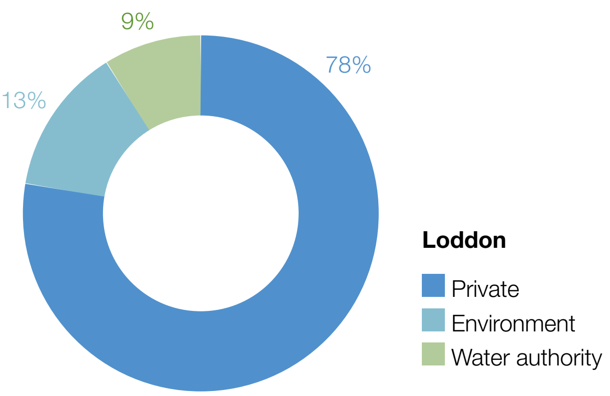
Storage manager – Goulburn-Murray Water

Environmental water holders – Victorian Environmental Water Holder, Commonwealth Environmental Water Holder

Did you know ...?

Dja Dja Wurrung people know the Loddon River as *Bulutjang*.

Environmental flows can provide a cue for native fish to move within a system. When environmental flows were released in the Loddon River and Pyramid Creek in 2017, 40 percent of tracked fish moved at least 40 kilometres upstream, and one even travelled 140 kilometres!



Proportion of water entitlements in the Loddon basin held by private users, water corporations or environmental water holders.

Top: Loddon River, by North Central CMA
Centre: Rakali at Longs Rd, Loddon River, by North Central CMA
Above: Golden perch release, Pyramid Creek, by Arthur Rylah Institute

5.7.1 Loddon River system (including Tullaroop, Serpentine and Pyramid creeks)

System overview

The Loddon River flows from the Great Dividing Range in the south to the River Murray in the north. Tullaroop Creek is the main tributary in the upper Loddon River system. The middle section of the Loddon River is characterised by many distributary streams and anabranches that carry water away from the river onto the floodplain. The lower Loddon River is joined by Pyramid Creek at Kerang, at which point the Loddon becomes part of the River Murray floodplain.

Three main storages are located on the Loddon River: Cairn Curran, Tullaroop and Laanecoorie reservoirs. Downstream of Laanecoorie Reservoir, river flows are regulated by the operation of the Bridgewater, Serpentine, Loddon and Kerang weirs.

Water for the environment can be delivered to the Loddon River from Cairn Curran or Tullaroop reservoirs or from the Goulburn system via the Waranga Western Channel, which intersects with the Loddon River at Loddon Weir. Water is provided to Pyramid Creek through releases from Kow Swamp, which receives water diverted from the River Murray at Torrumbarry Weir. Water is diverted from the Loddon River to Serpentine Creek and to the Loddon Valley Irrigation Area to supply agriculture.

The highly regulated nature of the Loddon system provides both challenges and opportunities for effective management of water for the environment. The ability to manipulate the timing of releases at multiple locations provides opportunities to accomplish environmental outcomes at discrete locations. However, coordinating environmental flows and consumptive flows is difficult through the irrigation season, especially when irrigation demand is high. This can lead to constraints in the timing and delivery of water for the environment or higher-than-recommended flows upstream of Loddon Weir. The structures used for managing irrigation water form barriers in the waterway, restricting continuity and the ability to achieve outcomes for native fish and possibly platypus.

Environmental values

The Loddon River system supports platypus, rakali (water rats) and several species of native fish. Streamside vegetation varies in condition depending on the recent water regime, the extent of clearing and historic and current land management practices. Those areas remaining relatively intact support a variety of woodland birds and other native animals. Important plant species across the system include cane grass, tangled lignum, black box and river red gum.

Although fish populations in the Loddon system are affected by the many barriers caused by weirs and reservoirs, a large range of species are still found through the catchment. Native fish are most abundant and diverse in the upper catchment. River blackfish are found in Serpentine Creek and rare Murray-Darling rainbow fish are found in the middle and lower sections of the Loddon River.

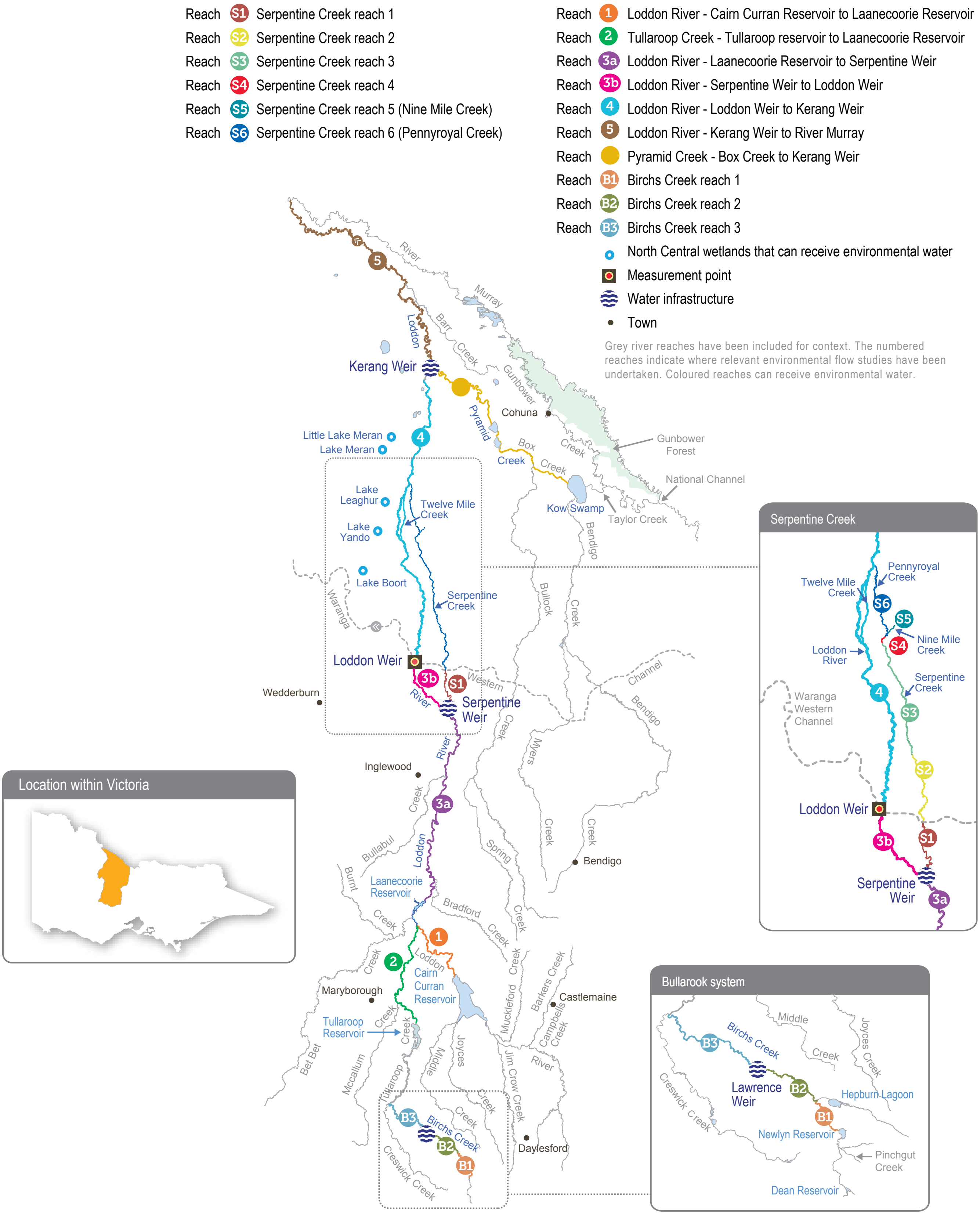
The highest-priority reach for environmental watering is from Loddon Weir to Kerang Weir. The reach does not carry irrigation water, and it relies heavily on environmental flows to maintain its environmental condition. Environmental flows to this reach aim to improve the condition of riparian vegetation, maintain water quality and increase the abundance and diversity of native fish. Environmental flows are delivered to the upper Loddon River, Tullaroop Creek and Serpentine Creek to maintain or increase populations of river blackfish and platypus.

Pyramid Creek and the lower Loddon River support large-bodied fish (such as golden perch, Murray cod and silver perch) and are important corridors for fish migration between the Loddon and Murray systems. Engineering works to provide fish passage at the Chute, Box Creek regulator, Kerang Weir, Fish Point Weir and Little Murray Weir on the Little Murray River in recent years have been important in reopening these migration routes. The Arthur Rylah Institute has monitored fish movement and populations in Pyramid Creek and the lower Loddon River since 2017, and results have indicated that the combined Loddon-Pyramid flow is stimulating native fish movement through the fishways.

Environmental objectives in the Loddon River system

Increase populations of small and large-bodied native fish and opportunities for movement between habitats
Maintain and enhance the channel form and features including deep pools and benches Maintain the condition of suitable substrate, to maintain ecosystem processes Engage floodrunners, distributary channels, anabranches and backwaters
Increase the population and recruitment of resident platypus Maintain the rakali (water rat) population
Maintain the riparian and floodplain vegetation and facilitate the recruitment of woody and non-woody vegetation Maintain and increase the extent of in-stream vegetation Limit the encroachment of fringing vegetation into the stream channel
Maintain/increase the diversity and productivity of waterbugs and waterbug functional feeding groups, to drive productive and dynamic foodwebs
Maintain water quality, to support aquatic animals and minimise the risk of blackwater events

Figure 5.7.1 The Loddon system



Recent conditions

Rainfall in the Loddon catchment was much lower than average throughout most of 2018–19, although several storms in December meant rainfall for that month was above average. Natural streamflow and inflows to storages were very low throughout 2018–19, as most rainfall was absorbed by soils and did not generate much run-off. Despite the very dry conditions, there was adequate water available to deliver all planned flows for the Loddon River, Pyramid Creek and Serpentine Creek under a dry scenario, but the presence of blue-green algae in Loddon and Kerang weirs prevented delivery of freshes to the Loddon River in autumn.

While only one summer fresh could be delivered in the Loddon River, low flows were delivered throughout the year, meeting targets in the priority reach (reach 4). A fresh of up to 400 ML per day was delivered to reach 4 in spring, and it was timed to coincide with an environmental flow in Pyramid Creek to cue native fish movement.

Water for the environment was used to deliver two summer/autumn freshes and one winter/spring fresh to Serpentine Creek in 2018–19. A minimum operational flow of 7 ML per day was provided at other times. The summer freshes helped alleviate low-dissolved-oxygen levels in reach S1 during prolonged hot weather in January 2019. Environmental flows delivered to Serpentine Creek subsequently flowed through to Nine Mile Creek, where they supported vegetation and aquatic animals.

Two environmental flows were provided to Pyramid Creek during 2018–19, to support North Central CMA's *Native Fish Recovery Plan – Gunbower and Lower Loddon*. The first was delivered in spring and involved coordinated releases through Pyramid Creek and reach 4 of the Loddon River, to attract fish from the lower Loddon and River Murray to move through Kerang Weir and the Box Creek regulator fishway at Kow Swamp. The second environmental flow to Pyramid Creek was delivered at the end of the irrigation season in mid-May to prevent fish becoming stranded when the irrigation system was drained. Target environmental flows in Pyramid Creek could not be achieved without the cooperation and expertise of the storage manager, Goulburn-Murray Water.

Scope of environmental watering

Table 5.7.1 describes the potential environmental watering actions that may be delivered in 2019–20, their functional watering objectives (that is, the intended physical or biological effect of the watering action) and the longer-term environmental objective they support. Each environmental objective relies on one or more potential environmental watering actions and their associated physical or biological functions.

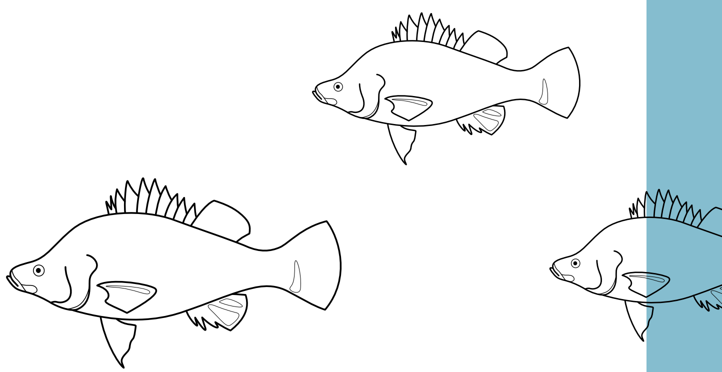


Table 5.7.1 Potential environmental watering actions and objectives for the Loddon River system

Potential environmental watering action	Functional watering objective	Environmental objective
Loddon River (reach 1)		
Summer/autumn fresh (one to four freshes of 35–80 ML/day for one to three days during December to May)	• Flush fine sediment from hard surfaces • Increase the water level, to promote the growth of fringing emergent macrophytes • Increase connectivity to promote the local movement of adult fish and encourage juvenile fish and platypus dispersal in autumn • Wet submerged wood to flush old biofilms and promote new biofilm growth	
Spring fresh (one fresh of 400–700 ML/day for four to five days during September to October)	• Redistribute fine sediment on bars and benches • Flush accumulated leaf litter, to increase productivity and reduce the risk of hypoxic blackwater event in summer • Increase the wetted area, to promote the recruitment and maintenance of riparian vegetation on the banks and benches • Stimulate the movement of Murray cod, to encourage breeding	
Tullaroop Creek (reach 2)		
Summer/autumn fresh (one to four freshes of 30–40 ML/day for one to three days during December to May)	• Flush fine sediment from hard surfaces • Increase the water level, to promote the growth of fringing emergent macrophytes • Increase connectivity, to promote the local movement of adult fish and encourage juvenile fish and platypus dispersal in autumn • Wet submerged wood to flush old biofilms and promote new biofilm growth	
Spring fresh (one fresh of 200–400 ML/day for one to five days during September to October)	• Redistribute fine sediment on bars and benches • Flush accumulated leaf litter, to increase productivity and reduce the risk of hypoxic blackwater event in summer • Increase the wetted area, to promote the recruitment and maintenance of riparian vegetation on the banks and benches • Stimulate the movement of Murray cod, to encourage breeding	
Loddon River (reach 4)		
Summer/autumn fresh (one to three freshes of 50–100 ML/day for three to four days during December to May)	• Flush fine sediment from hard surfaces • Increase the water level, to promote the growth of fringing emergent macrophytes • Increase connectivity, to promote the local movement of fish and platypus including juvenile dispersal in autumn	
Winter/spring high flow (one high flow of 450–750 ML/day for six to 10 days during August to November)[1]	• Provide flow through flood runners • Scour accumulated sediment from pools • Flush accumulated organic matter from the bank and benches, to increase productivity and reduce the risk of hypoxic blackwater event in summer • Increase the wetted area, to promote the recruitment and growth of riparian and emergent vegetation • Stimulate native fish movement and breeding	

Table 5.7.1 Potential environmental watering actions and objectives for the Loddon River system *continued...*

Potential environmental watering action	Functional watering objective	Environmental objective
Summer/autumn low flow (25–50 ML/day during December to May)	• Maintain an adequate depth in pools for aquatic plants and to provide habitat for waterbugs, fish and rakali (water rats) • Provide continuous flow through the reach, to maintain water quality • Maintain connecting flows to support in-stream and fringing non-woody vegetation	
Winter/spring low flow (50–100 ML/day during June to November)	• Increase the water depth for fish, platypus and rakali (water rats) dispersal and to provide foraging habitat • Prevent silt and fine sediment settling on submerged wood and other hard surfaces • Prevent the growth of terrestrial plants in the river channel	
Autumn high flow (up to one high flow of 400 ML/day for 6–10 days during March to May)	• Trigger and facilitate the upstream movement of golden perch, silver perch and Murray cod older than one year	
Serpentine Creek (reach S1)[2]		
Winter/spring fresh (one fresh of 40–150 ML/day for two days during August to November)	• Maintain the channel form and scour pools • Provide connectivity for fish and waterbugs to access different habitat areas • Transport organic matter that has accumulated in the channel • Provide a cue for adult platypus to construct burrows above the higher water level	
Summer/autumn fresh (one to three freshes of 30–40 ML/day for one to three days during December to May)	• Maintain the channel form by engaging benches • Flush fine sediment and scour biofilms, to replenish the food supply • Transport organic matter that has accumulated in the channel • Provide flow variability to maintain the diversity of fringing vegetation • Provide a sufficient depth of water and variability of flow to maintain microbial biofilms	
Summer/autumn low flow (10–20 ML/day during December to May)	• Prevent notching of riverbanks by providing flow variability • Provide connectivity between pools to allow the dispersal of small-to-medium-bodied native fish • Wet exposed roots, leaf packs and woody debris, to provide habitat for aquatic animals • Provide sufficient flow to maintain water quality by re-oxygenating pools and preventing stagnation • Maintain foraging habitat for platypus • Maintain the wetted area to support in-stream aquatic vegetation (e.g. water ribbons, eel weed and milfoil)	

Table 5.7.1 Potential environmental watering actions and objectives for the Loddon River system *continued...*

Potential environmental watering action	Functional watering objective	Environmental objective
Winter/spring low flow (20–30 ML/day during June to November)	• Maintain spawning habitat for native fish • Wet exposed roots, woody debris, emergent vegetation and leaf packs, to provide habitat for aquatic animals • Maintain water quality by preventing stagnation • Provide flow variability, to maintain diversity of fringing vegetation • Provide a sufficient depth of water and variability of flow to maintain microbial biofilms	
Pyramid Creek and Loddon River (reach 5)		
Spring high flow (one high flow of 700–900 ML/day for 10 days during September to October)	• Trigger the migration, spawning and recruitment of native fish species including Murray cod • Maintain connectivity between habitats and improve water quality	
Autumn/winter low flow (90–200 ML/day during May to August)	• Maintain connectivity between pools and provide habitat for fish and waterbugs outside of the irrigation season • Improve water quality by reducing salinity levels • Enhance the wetted area to maintain and promote the growth of fringing emergent (non-woody) vegetation along the lower banks of the channel • Redistribute fine sediment on benches and bars	
Autumn high flow (up to one high flow of 700–900 ML/day for 10 days during March to May)	• Trigger the migration, spawning and recruitment of native fish species including Murray cod • Facilitate the upstream movement of golden perch, silver perch and Murray cod older than one year • Maintain connectivity between habitats and improve water quality • Facilitate platypus dispersal	

1 *Due to potential inundation of private land, environmental flows above 450 ML per day in reach 4 will not be provided without the agreement of potentially affected landholders.*

2 *Flows in Serpentine Creek will be allowed to either return to the Loddon River via the channel system or continue down Pennyroyal Creek, Bannacher Creek and Nine Mile Creek with the agreement of landholders.*

Scenario planning

Table 5.7.2 outlines the potential environmental watering and expected water use under a range of planning scenarios.

The highest-priority reach for environmental flows in the Loddon system is the Loddon River between Loddon Weir and Kerang Weir (i.e. reach 4). Reach 4 is a high priority because it receives little to no consumptive water and therefore completely relies on passing flows, unregulated spills from storage and environmental flows. There are also many system constraints that limit the ability to deliver flows when a lot of water is available. Pyramid Creek is also a priority reach, because it provides a corridor for large-bodied native fish to move between critical habitat in the River Murray, Kow Swamp and Gunbower Creek.

Under drought and dry conditions, the highest-priority watering actions in both reaches will aim to maintain the quality and quantity of aquatic habitat for native fish. In reach 4, this will involve supplementing passing flows, particularly under a drought scenario. Passing flows for reach 4 are reduced when the combined storage volumes in Cairn Curran and Tullaroop reservoirs are less than 60,000 ML according to rules in the VEWH's Loddon River bulk entitlement. This is likely to occur in the first half of the year under a drought scenario, and in that case water for the environment will help meet minimum environmental low-flow requirements. Occasional freshes in summer and autumn are also planned under all scenarios, to flush pools and prevent adverse water quality.

Pyramid Creek carries a large volume of consumptive water during the irrigation season, but flows can drop significantly outside the irrigation season. Under all scenarios, water for the environment will be used in Pyramid Creek to supplement flows in autumn and winter, so flows of at least 200 ML per day will be maintained to ensure there is sufficient habitat for fish and other aquatic animals outside the irrigation season.

Under average and wet conditions, water for the environment will be used to provide high flows in the Loddon River in spring and possibly autumn, to cue the movements, spawning and recruitment of large-bodied native fish (such as Murray cod, golden perch and silver perch). These flows will coincide with similar releases in Pyramid Creek, which help to achieve the required flow magnitude at Kerang Weir needed to encourage fish to move upstream into the system from the River Murray, and to allow some fish to access habitats in reach 4.

The Loddon River upstream of Serpentine Weir and Serpentine Creek carry operational low flows for most of the year. Water for the environment will be mainly used in these reaches to provide occasional freshes to maintain water quality and support riparian vegetation.

Up to 5,100 ML is prioritised for carryover into 2020–21. This water is needed for summer/autumn freshes and for a spring high flow if conditions remain dry in 2019–20.

While there is expected to be enough water available to meet the tier 1a potential watering actions under all scenarios, deliveries of water for the environment in the Loddon system can also be constrained by the physical capacity of the infrastructure and capacity-share rules. For example, water for the environment can only be delivered through the Waranga Western Channel when there is spare capacity after irrigation demands have been met. The VEWH and North Central CMA work with Goulburn-Murray Water to optimise environmental outcomes within system constraints. These cooperative arrangements include adjusting the timing of deliveries of water for the environment to avoid capacity constraints and modifying the rate and timing of irrigation deliveries and transfers, to support environmental outcomes.

Table 5.7.2 Potential environmental watering for the Loddon River system under a range of planning scenarios

<table>
<tr><th>Planning scenario</th><th>Drought</th><th>Dry</th><th>Average</th><th>Wet</th></tr>
<tr><td>Expected river conditions</td><td>• Negligible contributions from unregulated reaches and tributaries of the Loddon River, consumptive water deliveries in the irrigation season
• Reduced passing flows in autumn and winter likely</td><td>• Small contributions from unregulated reaches and tributaries of the Loddon River contributing to low flows, consumptive water deliveries in the irrigation season</td><td>• Unregulated flows will provide low flows and multiple freshes, most likely in winter and spring
• Consumptive water deliveries in the irrigation season
• No spill likely</td><td>• Spills from Loddon system storages will provide extended-duration high flows and overbank flows most likely in late winter to spring</td></tr>
<tr><td>Expected availability of water for the environment</td><td>• Up to 13,800 ML</td><td>• Up to 16,200 ML</td><td>• Up to 21,100 ML</td><td>• Up to 21,100 ML</td></tr>
<tr><td colspan="5">Loddon River (reach 1) and Tullaroop Creek</td></tr>
<tr><td>Potential environmental watering – tier 1a (high priorities)</td><td colspan="4">• One to four summer/autumn freshes
• One spring fresh</td></tr>
<tr><td colspan="5">Loddon River (reach 4)</td></tr>
<tr><td>Potential environmental watering – tier 1a (high priorities)</td><td colspan="2">• One to three summer/autumn freshes
• Summer/autumn low flows
• Winter/spring low flows</td><td>• Three summer/autumn freshes
• One winter/spring high flow
• Summer/autumn low flows
• Winter/spring low flows</td><td>• Three summer/autumn freshes
• One winter/spring high flow
• Summer/autumn low flows
• Winter/spring low flows
• One autumn high flow</td></tr>
<tr><td>Potential environmental watering – tier 1b (high priorities with shortfall)</td><td colspan="2">• One winter/spring high flow
• Increased magnitude of summer/autumn fresh</td><td>• One autumn high flow
• Summer low flow magnitude delivered at upper range</td><td>• N/A</td></tr>
<tr><td>Potential environmental watering – tier 2 (additional priorities)</td><td>• Low flow magnitudes delivered at upper ranges</td><td>• Winter low flow magnitude delivered at upper range
• One autumn high flow</td><td>• N/A</td><td>• N/A</td></tr>
<tr><td colspan="5">Serpentine Creek (reach S1)</td></tr>
<tr><td>Potential environmental watering – tier 1a (high priorities)</td><td colspan="4">• One winter/spring fresh
• One to three summer/autumn freshes
• Summer/autumn low flows
• Winter/spring low flows</td></tr>
</table>

Table 5.7.2 Potential environmental watering for the Loddon River system under a range of planning scenarios *continued...*

Planning scenario	Drought	Dry	Average	Wet
Potential environmental watering – tier 1b (high priorities with shortfall)	• Increased magnitude of winter/spring fresh		• Low flow magnitudes delivered at upper ranges	• N/A
Potential environmental watering – tier 2 (additional priorities)	• Low flow magnitudes delivered at upper ranges		• N/A	
Pyramid Creek and Loddon River (reach 5)				
Potential environmental watering – tier 1a (high priorities)	• Autumn/winter low flows		• One spring high flow • Autumn/winter low flows	
Potential environmental watering – tier 1b (high priorities with shortfall)	• One spring high flow		• Autumn high flow	
Possible volume of water for the environment required to achieve objectives[1]				
Loddon River (reach 1 and reach 4), Tullaroop Creek and Serpentine Creek	• 8,800 ML (tier 1a) • 3,800 ML (tier 1b) • 7,700 (tier 2)	• 6,000[2] ML (tier 1a) • 6,500 ML (tier 1b) • 7,300 (tier 2)	• 12,500 ML (tier 1a) • 7,300 ML (tier 1b) • 6,900 (tier 2)	• 9,000 ML (tier 1a)
Pyramid Creek and Loddon River (reach 5)	• 2,000 ML (tier 1a)[3] • 1,000 ML (tier 1b)		• 3,000 ML (tier 1a) • 1,000 ML (tier 1b)	
Priority carryover requirements	• 4,500–5,100 ML			

1 *Water for the environment requirements for tier 2 actions are additional to tier 1 requirements.*

2 *Environmental watering demands under a dry scenario are lower than under a drought scenario because it is expected that combined storage levels of Tullaroop and Cairn Curran reservoirs will remain above 60 GL, meaning passing flows will not be reduced and less water for the environment will be required for supplementing passing flows.*

3 *Represents the estimated volume of water required to underwrite losses associated with the delivery of consumptive water en route through Pyramid Creek.*

5.7.2 Boort wetlands

System overview

The Boort wetlands are on the floodplain west of the Loddon River, downstream of Loddon Weir. They consist of temporary and permanent freshwater lakes and swamps: Lake Boort, Lake Leaghur, Lake Yando, Little Lake Meran and Lake Meran. Together, the Boort wetlands cover over 800 ha. There are several other wetlands in the district, but they are currently not managed with water for the environment.

The natural watering regimes of wetlands throughout the broader Loddon system have been substantially modified by the construction of levees and channels across the floodplain and by the construction and operation of reservoirs and weirs along the Loddon River. Water is delivered to the Boort wetlands through Loddon Valley Irrigation Area infrastructure.

The availability of water for the environment for the Boort wetlands is closely linked to water available for the Loddon River system. The ability to deliver water for the environment to the wetlands is sometimes limited by channel-capacity constraints. The VEWH and North Central CMA work with the storage manager (Goulburn-Murray Water) to best meet environmental objectives within capacity constraints.

Environmental values

The Boort wetlands provide habitat for a range of plant and animal species. At Lake Yando, 12 rare plant species have been recorded including the jerry-jerry and water nymph. Bird species recorded at Lake Boort, Lake Leaghur and Lake Meran include the white-bellied sea eagle, Latham's snipe and eastern great egret. Little Lake Meran is a swampy woodland with black box trees on the highest wet margins and river red gums fringing the waterline.

Environmental watering objectives in the Boort wetlands

Increase the population of large and small-bodied fish species
Increase the diversity and population of native frogs including by enhancing breeding opportunities
Maintain the population of freshwater turtles, in particular Murray River turtles
Rehabilitate and increase the extent of emergent and aquatic vegetation (aquatic herblands, tall marsh), intermittent swampy woodland and riverine chenopod woodland Maintain the health and restore the distribution of river red gums and associated floristic community across the wetland bed Maintain the extent and restore the health of black box vegetation
Support a high diversity of wetland birds by enhancing feeding and breeding conditions

Recent conditions

Rainfall throughout the Loddon catchment and the Boort wetlands was drier than average throughout 2018–19, but summer storms resulted in above-average rainfall in December. The Boort wetlands received no natural inflows, and the very hot and dry conditions over summer and autumn accelerated drying in the wetlands that held water from previous years.

Lakes Boort, Leaghur, Yando and Meran were all naturally flooded in spring 2016 and water levels are continuing to recede, allowing wetland plants an opportunity to establish. Little Lake Meran was the only lake in the Boort wetlands system to receive water for the environment in 2018–19. Little Lake Meran is normally disconnected from the Loddon floodplain, except during exceptionally high floods (such as in 2011). After flooding in 2011, river red gums germinated around the edges of the lake. Water for the environment was delivered to Little Lake Meran in May 2018, and follow-up watering was delivered in August and September, to promote the growth of naturally recruited river red gums and fringing vegetation.

Scope of environmental watering

Table 5.7.3 describes the potential environmental watering actions that may be delivered in 2019–20, their functional watering objectives (that is, the intended physical or biological effect of the watering action) and the longer-term environmental objective they support. Each environmental objective relies on one or more potential environmental watering actions and their associated physical or biological functions.

Table 5.7.3 Potential environmental watering actions and objectives for the Boort wetlands

Potential environmental watering action	Functional watering objective	Environmental objective
Loddon River (reach 1)		
Lake Meran (top-up in spring to maintain critical water level)	• Increase the water depth to maintain an appropriate water temperature for aquatic animals and provide a refuge for freshwater turtles, waterbirds and fish, helping to support recruitment • Promote the growth and increase the extent of lake bed herbland vegetation by wetting the wetland fringe	
Lake Yando (fill in spring, with top-ups as required to support waterbird breeding)	• Provide moisture to promote the germination and recruitment of river red gums and maintain the existing mature trees • Support the growth of aquatic and semi-aquatic plant species, providing habitat for aquatic animals	
Lake Yando (partial fill in autumn, if fill in spring is not possible)[1]		
Lake Leaghur (partial fill in autumn)	• Prime the wetland for spring watering in 2020–21 by stimulating the early germination of wetland vegetation, attracting waterbirds to feed and breed in early spring/summer 2020 as the weather warms up • Promote winter feeding conditions for waterbirds and frogs • Reduce the volume of water required to fill the wetland in spring 2020–21	
Wetland drying		
Little Lake Meran and Lake Boort (promote natural drawdown/drying)	• These wetlands will be in a drying phase in 2019–20 • Promote the establishment and growth of fringing vegetation and herbland species	

[1] *A partial fill in autumn will be triggered if a fill in spring is not possible due to supply shortfall or delivery constraints.*

Scenario planning

Table 5.7.4 outlines the potential environmental watering and expected water use under a range of planning scenarios.

Supplying a top-up to Lake Meran is prioritised under all scenarios. This is to ensure the wetland remains at a level between 77.3 and 77.8 m AHD. The wetland needs to be permanently maintained within this range to prevent the irreversible loss of significant species, in particular Murray River turtles. Lake Yando has been dry for about 20 months and filling it in 2019–20 is a priority under dry-wet scenarios, to support vegetation outcomes. A partial fill of Lake Leaghur is recommended in autumn under average to wet scenarios, to prime the wetland for a complete fill in spring of the following water year.

All other wetlands will be allowed to draw down to a minimum level or to dry completely. This will provide an important dry period, to promote the growth of herbland plants and fringing vegetation.

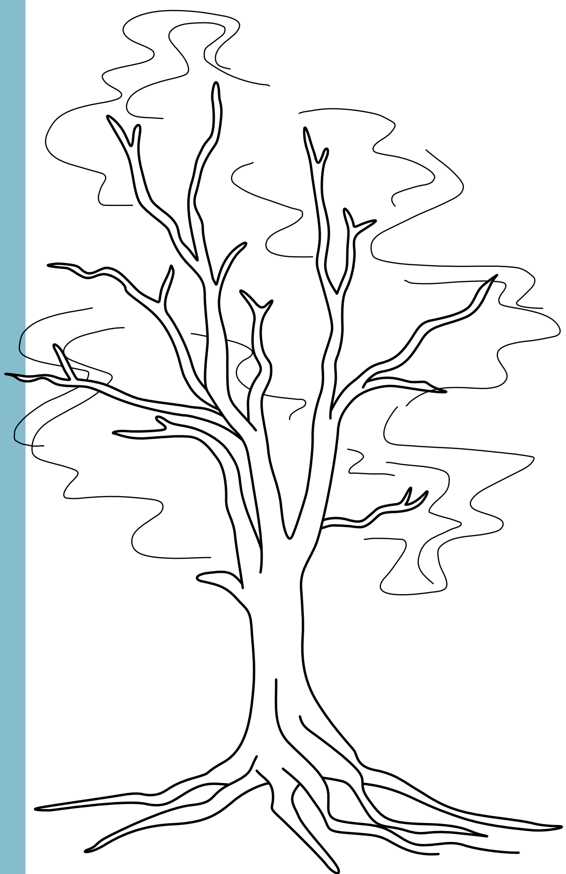
Most wetlands are expected to fill naturally from large overland floods under a wet scenario.

Table 5.7.4 Potential environmental watering for the Boort wetlands under a range of planning scenarios

Planning scenario	Drought	Dry	Average	Wet
Expected river conditions	• No natural inflows to wetlands	• Minimal natural inflows to wetlands	• Periods of high flows combined with localised catchment contributions, which are expected to provide minor inflows to wetlands	• Extended durations of high flows and overbank flows from creeks and flood runners, which fill most wetlands
Potential environmental watering – tier 1 (high priorities)[1]	• Lake Meran	• Lake Meran • Lake Yando	• Lake Meran • Lake Yando • Lake Leaghur	• Lake Meran • Lake Yando • Lake Leaghur
Potential environmental watering – tier 2 (additional priorities)	• Lake Yando • Lake Leaghur	• Lake Leaghur	• N/A	• N/A
Possible volume of water for the environment required to achieve objectives[2]	• 2,000 ML (tier 1a) • 2,200 ML (tier 2)	• 3,200 ML (tier 1a) • 1,000 ML (tier 2)	• 4,200 ML (tier 1a)	• 4,200 ML (tier 1a)

1 *It is not possible to distinguish between tier 1a and 1b demands for the Boort Wetlands as there is no individual entitlement (and therefore no expected supply volume) for them. Rather the water is shared and prioritised across several systems. Wetlands are listed in priority order for tier 1 and tier 2 under all climate scenarios.*

2 *Water for the environment requirements for tier 2 actions are additional to tier 1 requirements.*



5.7.3 Birch Creek

System overview

Birch Creek is a tributary of the Loddon River located in the southernmost part of the catchment. The creek rises in the ranges north-east of Ballarat and flows north-west through Newlyn and Smeaton before joining Tullaroop Creek near Clunes. The lower parts of the catchment are extensively cleared where the creek meanders through an incised basaltic valley. The creek contains a regionally significant platypus community and a vulnerable river blackfish population.

Birch Creek is part of the broader Bullarook system which contains two small storages — Newlyn Reservoir and Hepburn Lagoon — which provide water for irrigation and urban supply. The storages fill and spill during winter or spring in years with average or above-average rainfall.

Birch Creek receives tributary inflows from Rocky Lead, Langdons, Lawrence and Tourello creeks. In the downstream reaches, Birch Creek is highly connected to groundwater, which provides baseflows to the creek in most years.

The VEWH is allocated 100 ML in Newlyn Reservoir on 1 December each year, provided that seasonal determinations in the Bullarook system are at least 20 percent. Any unused allocation from 1 December can be carried over until 30 November of the following water year, but if Newlyn Reservoir spills from 1 July to 30 November, the volume held in carryover is lost. Any water remaining on 30 November is forfeited. When seasonal determinations are below 20 percent, the VEWH does not receive an allocation, and the system's resources are shared equitably to protect critical human and environmental needs.

Environmental values

Birch Creek supports threatened aquatic plants and its deep pools provide habitat for aquatic animals during dry periods. The creek contains native fish including regionally significant populations of river blackfish and mountain galaxias as well as flat-headed gudgeon and Australian smelt. Recent monitoring indicates that platypus are present throughout the entire creek.

The removal of willows along the creek in 2018 has led to observed improvements in in-stream vegetation and presence of small-bodied fish.

Environmental objectives in Birch Creek

Increase the population and diversity of small-to-medium-bodied native fish including river blackfish, mountain galaxias, flat-headed gudgeon and Australian smelt, and provide opportunities for movement between pool habitats
Maintain the breeding population of platypus and provide opportunities for its dispersal to Creswick Creek and Tullaroop Creek
Maintain and improve the diversity and abundance of in-stream aquatics Maintain a diverse variety of fringing and riparian native vegetation communities
Increase the population of waterbugs and the diversity of functional groups
Maintain water quality to support aquatic life and ecological processes

Recent conditions

The Birch Creek catchment had below-average rainfall in winter and spring 2018–19, with October being well-below average. Despite the dry winter and spring, flows in the creek were maintained from groundwater baseflow, consumptive water and small releases from Hepburn Lagoon. Summer and autumn were warmer and drier than average, and flows in Birch Creek throughout these seasons were low, but sufficient to maintain aquatic habitat and water quality.

Newlyn Reservoir did not spill in 2018–19, but tributary inflows and groundwater discharge contributed to meeting environmental flow objectives in Birch Creek throughout the year; and no environmental flows were delivered in 2018–19.

The system allocation was above 20 percent on 1 December 2018, meaning the 2018 allocation of water for the environment became available. The 2018 reserve will be available for use until 30 November 2019.

Significant willow removal occurred along Birch Creek in 2018, particularly in the Smeaton area. This may have increased flow rates, but this has not been confirmed. Processes such as scouring and sediment transport are more evident since the removal of the trees, and observations indicate the recolonisation of in-stream vegetation and small-bodied fish.

Scope of environmental watering

Table 5.7.5 describes the potential environmental watering actions that may be delivered in 2019–20, their functional watering objectives (that is, the intended physical or biological effect of the watering action) and the longer-term environmental objective they support. Each environmental objective relies on one or more potential environmental watering actions and their associated physical or biological functions.

Table 5.7.5 Potential environmental watering actions and objectives for Birch Creek

Potential environmental watering action	Functional watering objective	Environmental objective
Spring fresh (one fresh of 30 ML/day for three days during September to November)	• Maintain and support the growth of streamside vegetation by providing moisture and sediment to the bank and benches • Scour organic matter that has accumulated in the channel and cycle nutrients throughout the creek • Wet benches and smaller channels, to provide increased habitat and refuge for small fish • Freshen refuge pools and provide connectivity between pools for fish and platypus movement	
Summer/autumn freshes (up to three freshes of 10 ML/day for three days during March to April)	• Increase the water depth, to maintain and support the growth of in-stream aquatic vegetation • Expand riffle/run areas to provide waterbug habitat • Top up pools to refresh water quality (particularly dissolved oxygen) and enhance connectivity between pools for fish and platypus movement	

Scenario planning

In drought or dry scenarios, seasonal determinations in the Bullarook system (which supports allocations for Birch Creek) will likely be less than 20 percent on 1 December 2019. Under these scenarios, the VEWH will not receive an allocation.

The water that was allocated to the VEWH on 1 December 2018 will be retained until 30 November 2019 in accordance with entitlement rules. In this case, delivery of a spring fresh using carryover is a priority, to bolster the condition of the creek in the lead-up to summer. Entitlement rules do not allow the carryover volume to be held beyond 30 November, so they cannot be used for higher-priority flows in summer and autumn. If the seasonal determination is less than 20 percent on 1 December 2019, the VEWH will be entitled to an equitable share of the available water resources in the Bullarook system, which will be managed to consider both critical human and environmental needs.

Under an average-to-wet scenario, high rainfall will provide flows to Birch Creek throughout winter and spring, recharging groundwater aquifers. Any water allocated to the VEWH on 1 December 2019 may be used to provide a summer/autumn fresh during March or April 2020. However, it is more likely that there will be sufficient flows in Birch Creek provided by groundwater discharge, and the unused water for the environment will probably be carried over for use in the following water year.

Table 5.7.6 outlines the potential environmental watering and expected water use under a range of planning scenarios.

Table 5.7.6 Potential environmental watering for Birch Creek under a range of planning scenarios

Planning scenario	Drought	Dry	Average	Wet
Expected river conditions	• Reservoir spill unlikely • Flows extremely low in winter/spring • Limited irrigation releases due to low allocations	• Reservoir spill possible • Low flows in winter/spring if no spills occur • Moderate irrigation releases	• Reservoir spills certain in winter/spring • Some unregulated flows through summer/autumn	
Expected availability of water for the environment	• 100 ML (carryover)	• 100–200 ML (carryover and allocation)	• 100 ML (allocation)[1]	
Potential environmental watering – tier 1a (high priorities)	• One spring fresh	• One spring fresh • One to three summer/autumn freshes	• One to three summer/autumn freshes	
Possible volume of water for the environment required to achieve objectives	• 100 ML (tier 1a)	• 100–200 ML (tier 1a)	• 100 ML (tier 1a)	
Priority carryover requirements	• If the 100 ML allocation is received on 1 December 2019 and Birch Creek is in good condition over summer/autumn, carry over 100 ML allocation into 2020–21 water year, for use by 30 November 2020			

[1] *Under an average-wet scenario, it is likely that Newlyn Reservoir will spill before 30 November 2019, losing the 100 ML carryover from December 2018.*