Section 5

Northern Region

5.1 Northern Region overview

The Northern Region has six river systems, four major floodplain sites and many wetlands that can receive environmental water. The Broken, Campaspe, Goulburn, Loddon and Ovens river systems are tributaries of the River Murray. The five major floodplain sites along the River Murray corridor are Barmah Forest, Gunbower Forest, Hattah Lakes and Lindsay, Wallpolla and Mulcra islands. The other wetlands are distributed across the Broken, Goulburn, Loddon and Murray floodplains.

The water systems of the Northern Region are often 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.

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 planning and delivery 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 these are often broader in scope and cover additional values (such as frogs, turtle, waterbugs and physical processes like sediment movement). There are also significant benefits for many 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. Delivery of water for the environment occurs in the same way, with an increasing 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)
- delivering flows through Victorian and NSW tributaries of the River Murray to encourage juvenile golden perch and silver perch to migrate from their nursery habitats in the Darling River and mid-Murray to increase populations throughout the southern-connected Murray–Darling Basin.

The VEWH holds environmental entitlements for water recovered under interstate projects and agreements — Living Murray and River Murray Increased Flows (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 maximise the benefits of water for the environment held by the Commonwealth Environmental Water Office (CEWH) and delivered in Victorian systems. Delivery of Living Murray and Commonwealth water for the environment to meet Victorian water for the environment objectives is included in this section.

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, the 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 downstream sites, provided there are no adverse effects on the environment in Victoria. 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.

Environmental, social and economic 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 VEWH acknowledges the Traditional Owners of northern Victoria and pays respect to their Elders past, present and future. It recognises that water has significant cultural importance and value for Traditional Owners and Aboriginal people.

The Traditional Owner groups in and around northern Victoria include Barapa Barapa, Dhudhuroa, Latji Latji, Mutti Mutti, Nari Nari, Ngintait, Ngurai-illiam wurrung, Nyeri Nyeri, Tatti Tatti, Wadi Wadi, Wamba Wemba, Waywurru, Wegi Wegi, Yaithmathang, Yita Yita among others. The Registered Aboriginal Parties (RAPs) in the Northern Region are the Dja Dja Wurrung Clans Aboriginal Corporation, Taungurung Clans Aboriginal Corporation and Yorta Yorta Nation Aboriginal Corporation.

Two 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.

Examples of engagement with Traditional Owner groups and scoped opportunities for Traditional Owner aspirations with water for the environment in the Northern Region include:

- North Central CMA is working with Barapa Barapa and Dja Dja Wurrung to understand how management of water for the environment can better support Aboriginal aspirations
- North Central CMA is also planning to pump water for the environment for the first time to Reed Bed Swamp in Guttrum Forest. The presence of water in the wetland will support many culturally important plant and animal species as well as provide value for Barapa Barapa Traditional Owners. North Central CMA is also planning to provide employment opportunities for some Traditional Owners, to undertake aspects of the planning and monitoring of the pumping trial
- Barapa Barapa Traditional Owners have planned a cultural burn for the ceremonial ground at Reedy Lagoon in Gunbower Forest, to reduce weed cover and help with the identification and care of cultural sites. Water for the environment delivered to Gunbower Forest will help contain the fire and support the continuation of culture on Country
- Goulburn Broken CMA is planning to deliver water for the environment to maintain and improve turtle habitat in Barmah Forest. The broad-shelled turtle is a totemic species for the Yorta Yorta people
- North Central CMA is running a project to train Traditional Owners to do plant and animal assessments at Lake Boort, to inform future watering regimes
- Mallee CMA is engaging with Traditional Owners in the Mallee through its Aboriginal Reference Group.

Community considerations

When planning to use water for the environment, the potential social, economic, Aboriginal cultural, and community recreational benefits associated with the water's use are considered. Some scoped opportunities for shared community benefits in northern Victoria for 2018–19 include:

- timing water delivery to Gunbower Forest to achieve environmental objectives, while also providing enough time to deliver up to 85 GL of water for the environment to inundate the river red gum floodplain, floodrunners and wetlands without reducing other water users' access to delivery channels, and also by allowing water to draw down in early summer so Parks Victoria can prepare the national park for visitors during the busy summer holiday period
- improving movement and dispersal of fish (such as golden perch, silver perch and Murray cod in the Loddon River and Pyramid Creek), which increases fishing opportunities for anglers
- Mallee CMA improving walking, cycling and canoeing facilities at Merbein Common, to build on the success of providing environmental flows at Cowanna and Brickworks billabongs.

The indirect benefits of environmental watering also include improving amenity for campers at many reserves, crossings and towns along the Loddon and the Campaspe rivers including the popular Aysons Reserve on the Campaspe near Elmore: the reserve draws hundreds of campers during the school holidays.

The ability of the VEWH and its partners to deliver these benefits will depend on the weather, on climate variations, on the available water and on the way the system is being operated to deliver water for other purposes (such as for home, farm and business use).

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 in this seasonal watering plan will not be fully met without also 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 some issues.

Victorian and Australian government agencies, community groups and private landowners collectively implement programs and activities to protect and improve the environmental condition and function of land, soils and waterways throughout Victoria's catchments. *Water for Victoria* identifies 36 priority waterways across Victoria. In the Northern Region, the Campaspe River is an initial priority for investment in works to complement outcomes achievable with environmental flows in the river.

A good example of integrated catchment management is the North Central CMA's implementation of its *Gunbower and Lower Loddon Native Fish Recovery Plan*. Covering the Torrumbarry Irrigation Area and encompassing Gunbower Creek, Pyramid Creek, the lower Loddon River and the associated wetlands, the plan aims to increase native fish populations by improving waterway connectivity, habitat and flows. The VEWH and Goulburn-Murray Water are also collaborating on the plan, which has so far seen the:

- construction of the Box Creek regulator fish lock to allow fish to move into Kow Swamp from Pyramid Creek
- near-completion of the installation of an irrigation channel screen at Cohuna Weir to prevent native fish from entering an irrigation channel off the Cohuna Weir pool
- reinstatement of snags in Pyramid Creek to improve habitat for Murray cod, golden perch and silver perch
- use of a combination of irrigation water and water for the environment to provide flows to support fish movement and spawning.

Other examples of integrated catchment management in the region include:

- fox baiting in Barmah Forest by the Yorta Yorta Nation Aboriginal Corporation's works crew to protect turtle nests from predation
- the removal of willows from Birchs Creek
- the placement of artificial snags in Broken Creek and the Goulburn River in partnership with local fishing clubs.

Six natural resource management (NRM) agencies from Victoria, NSW and SA along the River Murray corridor are integrating programs under the Tri-State Murray NRM Regional Alliance. The alliance was formed in 2015 on the basis that NRM agencies that work in isolation may not provide the best and most cost-effective social, economic and environmental outcomes.

For more information about integrated catchment management programs in the Northern Region, see the Mallee, North Central, North East and Goulburn Broken regional catchment strategies and waterway strategies.

Flock of regent parrots at Hattah Lakes, by Mallee CMA

Seasonal outlook 2018–19

Very wet conditions in 2016–17 replenished storages across northern Victoria, resulting in good allocations at the start of 2017–18. Conditions in 2017–18 were mostly warm and dry, and as of May 2018, rainfall was needed to wet-up most catchments before there could be significant run-off into waterways and storages. Forecasts leading into the 2018–19 water year are generally neutral, with no clear indication of whether winter and spring 2018 rainfall will be above or below average.

Each year on 15 May, the Northern Victoria Resource Manager 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.

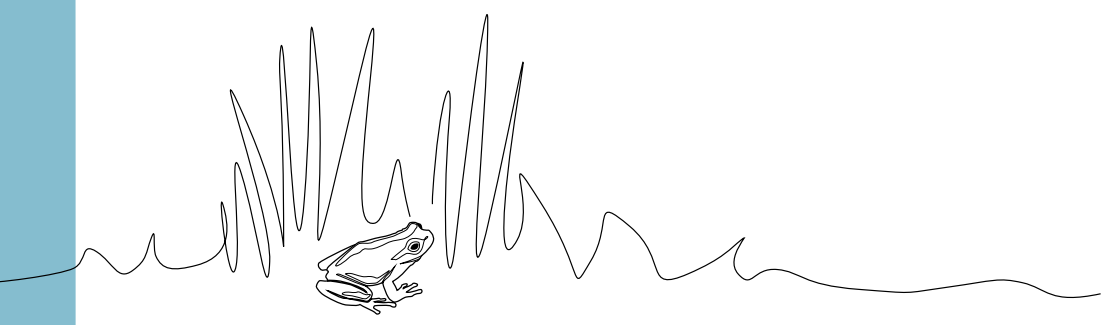
The 2018–19 outlook at 15 May 2018 indicated that early-season water availability is expected to be moderate in most systems. The opening, high-reliability entitlement allocation is expected to be at least 20 percent in the Goulburn and Loddon systems, 40 percent in the Murray system and 100 percent in the Campaspe system, with all systems expected to reach 100 percent by October 2018 under average conditions. Under an extreme dry to dry scenario – that is, if inflows are similar to the lowest 1 to 10 percent of inflows on record — most systems are unlikely to reach 100 percent high-reliability allocation. Allocation against low-reliability entitlements is possible in 2018–19 under average-to-wet conditions.

Demands for water for the environment in northern Victoria are usually highest in winter and spring. Opening allocations combined with some carryover should be sufficient to meet expected environmental demand for winter flows in creeks and rivers, as well as floodplain watering of Gunbower Forest. In 2017–18, a large volume (around 250,000 ML) of RMIF water was released from the Snowy storages because of Snowy Hydro releases for electricity generation. A portion of this RMIF was used in 2017–18 for environmental outcomes in the Murray system, with the remainder carried over to meet 2018–19 environmental demands in Victoria, NSW and SA.

Large rainfall events may result in unregulated flows that meet or exceed many of the environmental water flow targets 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 2017–18 may be deducted from environmental water 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. The MDBA developed the plan under the *Commonwealth Water Act 2007* and it became law in November 2012. The 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 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 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*.



5.2 Victorian Murray system

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

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

Environmental water holders – Victorian Environmental Water Holder, Murray–Darling Basin Authority (the Living Murray program), Commonwealth Environmental Water Holder

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 from a range of sources to meet demands in the Victorian Murray system. These include entitlements held by the VEWH, the Living Murray program and the CEWH; reuse of return flows; and in some instances use of consumptive 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 conditions. 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

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.

The Barmah Forest floodplain continues to be an important place for Traditional Owners and their Nations. The Registered Aboriginal Party (RAP) in the region is the Yorta Yorta Nation Aboriginal Corporation. Barmah Forest is jointly managed by the Yorta Yorta Nation and Parks Victoria, which were involved in preparing the Barmah Forest seasonal watering proposal.

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.

Social and economic values

The Barmah Forest supports a variety of recreational and tourism activities (such as bushwalking, boating, fishing, river cruises and birdwatching). Camping is popular along much of the 112 km frontage to the River Murray, a destination people choose for its majestic river red gums, sandy beaches and varied wildlife. Four canoe trails have been developed in the park and the forest also provides excellent fishing opportunities, particularly for Murray cod, golden perch, freshwater catfish and yabbies.

Barmah Forest is also valued for its European heritage values, largely associated with past forestry and grazing practices.

Environmental watering objectives in Barmah Forest

	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
	Maintain or increase the habitat available for turtles including the broad-shelled turtle
	Enable nutrient cycling (particularly carbon) between the floodplain and river through connectivity 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
	Maintain or increase available habitat for frogs
	Provide native fish with access to a range of floodplain, riverine and refuge habitats including by delivering variable flows that promote spawning

System overview

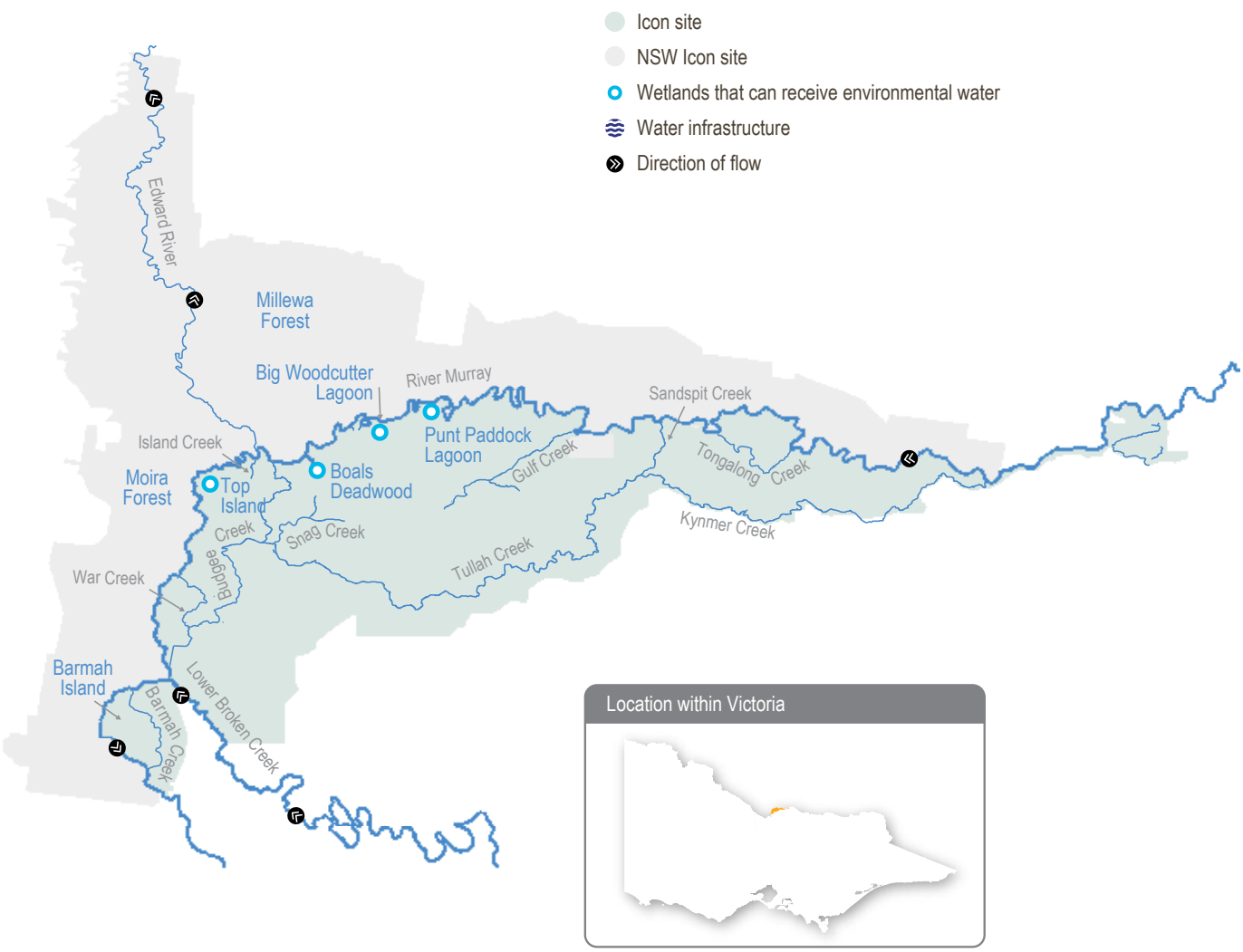
Flooding in the Barmah–Millewa Forest depends on flows in the River Murray. A natural narrowing of the river (known as the Barmah choke) restricts flow and results in overbank flooding when flows downstream of Yarrawonga Weir exceed the channel's capacity. This restriction influences both the operation of the 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 capped at 8,800 ML per day to prevent unseasonal flooding of the forest. Regulators along the River Murray remain closed during summer and autumn to restrict the inflow of water through lower-lying flood runners. The delivery of water to Barmah Forest is also constrained by an imposed flow constraint downstream of Yarrawonga Weir to prevent flooding of private land. The current cap limits releases to a maximum of 18,000 ML per day until the end of September and to 15,000 ML per day for the rest of the year. To overcome this constraint, most water for the environment delivered is directed via the forest regulators into either Barmah or Millewa forests to optimise outcomes within the operational constraints. 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 water en route to maximise environmental outcomes when possible. As Barmah–Millewa Forest is located towards the upper reaches of the River Murray, water for the environment delivered to the forest can often be used again at sites further downstream, as part of multisite watering events.

Aerial view of Boals Deadwood, by Keith Ward

Figure 5.2.1 Barmah Forest



Recent conditions

Barmah Forest was inundated in 2017–18 through managed and natural flooding. In 2017–18, a new approach to regulator operation was trialled at Barmah–Millewa Forest. Most forest regulators remained open between July and November 2017, as low flows (below choke capacity) were passed through to allow a more-natural rise and fall in the forest's waterways. This improved habitat in the forest's waterways by providing variable flows, and the same approach is planned for 2018–19.

A natural flood in August 2017 (35,000 ML per day) inundated 40 to 45 percent of the active floodplain; another in early December 2017 (20,000 ML per day) reached 17 to 20 percent of the floodplain. Flow levels between these two peaks were sustained by delivering water for the environment (15,000 ML per day through October and November 2017) to meet the water needs of the floodplain's marshlands.

Excellent vegetation and fish outcomes were recorded in 2017–18, including strong Moira grass growth and flowering as well as native fish breeding. Water for the environment was delivered to colonial waterbird breeding sites in Barmah Forest, with delivery ending early at one site due to the abandonment of nests after predation by feral pigs.

Scope of environmental watering

Table 5.2.1 shows potential environmental watering actions and their environmental objectives.

Table 5.2.1 Potential environmental watering actions and objectives for Barmah Forest

Potential environmental watering	Environmental objectives
Winter/spring low flows to various waterways in Barmah Forest (variable flow rates in July–December)	• Maintain fish and turtle habitat in forest waterways • Facilitate the movement of native fish between floodplain waterways and the river • Remove accumulated organic matter: 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 3 events of 500 ML/day for 8 days in October–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 3–5 days as required in November–April)	• Maintain critical drought-refuge areas in Barmah Forest • Protect fish and turtle populations in permanent waterways • 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 30–60 days between November–April) [1]	• Replenish refuge areas and maintain water quality in those areas • Maintain fish and turtle populations in permanent waterways • 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 for 3 months in September–December)[2]	• Provide flooding of sufficient duration to allow growth of floodplain marsh vegetation in open plains • Create foraging ground 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 4.5 months in September–February)	• Initiate and/or maintain breeding habitat for colonial nesting and flow-dependent waterbirds
Autumn/winter low flows (up to 5,000 ML/day downstream of Yarrawonga in May to August)	• Increase habitat for large-bodied native fish in the River Murray and anabranches in Barmah–Millewa Forest

[1] *May be delivered across multiple events.*

[2] *Water for the environment is limited to flow rates outlined in the MDBA's Objectives and Outcomes for River Operations in the River Murray System (MDBA, 2016).*

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. Demands for water for the environment vary significantly for Barmah Forest in response to natural conditions. Under dry conditions, objectives focus on maintaining refuges to sustain fish and turtle populations. Under average or wet conditions, the focus shifts to building resilience in the system by increasing responses 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 increase the recruitment and survival of young plants. Water for the environment may also be used from May to August to provide increased native fish habitat.

Targeted wetland watering may occur under a range of conditions to support the breeding of colonial nesting waterbirds and other flood-dependent birds.

Table 5.2.2 Potential environmental watering for 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	• 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 • Targeted wetland watering	• Winter/spring low flows • Spring/summer freshes (in-channel) • Spring/summer/ autumn low flows • Spring inundation of floodplain marshes • Targeted wetland watering • Autumn/winter low flows	• Winter/spring low flows • Spring/summer freshes (in-channel) • Spring inundation of floodplain marshes • Targeted wetland watering • Autumn/winter low flows
Possible volume of water for the environment required to achieve objectives[1]	• 30,000 ML (no return flows)	• 130,000 ML (with return flows)	• 550,000 ML (with return flows)	• 315,000 ML (with return flows)

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

Risk management

Environmental watering program partners have considered and assessed risks and identified mitigating strategies relating to environmental flows in 2018–19. Risks and mitigating actions are continually reassessed by program partners throughout the water year (see section 1.3.6).

Engagement

Table 5.2.3 shows the partners organisations with which Goulburn Broken CMA engaged when preparing the Barmah Forest seasonal watering proposal.

Seasonal watering proposals are informed by longer-term regional catchment strategies, regional waterway strategies, environmental flow studies, water management plans and other studies. These incorporate a range of environmental, cultural, social and economic perspectives and longer-term integrated catchment and waterway management objectives. For further details, refer to the *Goulburn Broken Regional Catchment Strategy* and the *Goulburn Broken Waterway Strategy*.

Table 5.2.3 Partners engaged in developing the Barmah Forest seasonal watering proposal

Partner and stakeholder engagement
• Commonwealth Environmental Water Office • Department of Environment, Land, Water and Planning • Murray–Darling Basin Murray–Darling Basin Authority (River Murray Operations and Living Murray program) • NSW National Parks and Wildlife Service • NSW Office of Environment and Heritage • Parks Victoria • Victorian Environmental Water Holder • Yorta Yorta Nation Aboriginal Corporation

5.2.2 Gunbower Creek and Forest

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.

Gunbower Creek and Forest continue to be important places for Traditional Owners and their Nations. The Registered Aboriginal Party (RAP) in the southern region is the Yorta Yorta Nation Aboriginal Corporation. Representatives from the RAP and from Barapa Barapa Nations Traditional Owners were engaged during the preparation of the Gunbower seasonal watering proposal.

Environmental values

Gunbower Forest contains a range of important environmental values including rare and diverse wetland habitats, vulnerable and endangered plants and animals and large areas of remnant vegetation communities (such as river red gum forest). The forest provides habitats for many bird species, and it is known to support internationally recognised migratory waterbirds.

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.

Social and economic values

The forest provides economic values through timber production, apiculture (bee keeping), educational courses, recreation and tourism. The forest supports numerous recreational activities when it is wet and dry. Popular activities include kayaking, canoeing, camping, photography and birdwatching. The Gunbower Heritage River Trail is a popular tourist attraction that passes through many Indigenous and European cultural heritage sites. The River Red Gum Drive is one of Victoria's iconic, four-wheel-drive routes that follows the River Murray through the Gunbower National Park.

Gunbower Creek is the major carrier for the delivery of irrigation supply to the surrounding agricultural land. The creek is also a hotspot for tourism, with businesses taking advantage of the presence of flows year-round and recreational activities (such as boating, canoeing, stand-up paddle-boarding, kayaking and fishing). The Cohuna Bridge to Bridge, a popular charity event held in autumn each year, allows participants to either swim or paddle along large sections of the creek or ride up to 50 km along the banks.

Environmental watering objectives in Gunbower Creek and Forest

	Maintain the health and support the recruitment of plants in permanent and semipermanent wetlands Maintain and improve the health of river red gums, black box and grey box communities
	Maintain and increase the healthy populations of large- and small-bodied native fish Provide flows for native fish (such as Murray cod, golden perch, carp gudgeon and freshwater catfish) to swim, feed and breed in Gunbower Creek
	Use flows to connect the floodplain to Gunbower Creek and the River Murray to enable native fish, turtles and carbon to move between them, supporting the life cycles of water-dependent plants and animals
	Provide feeding, breeding and refuge habitat for waterbirds including colonial nesting species
	Increase the population of frogs in the forest by providing feeding and breeding habitat

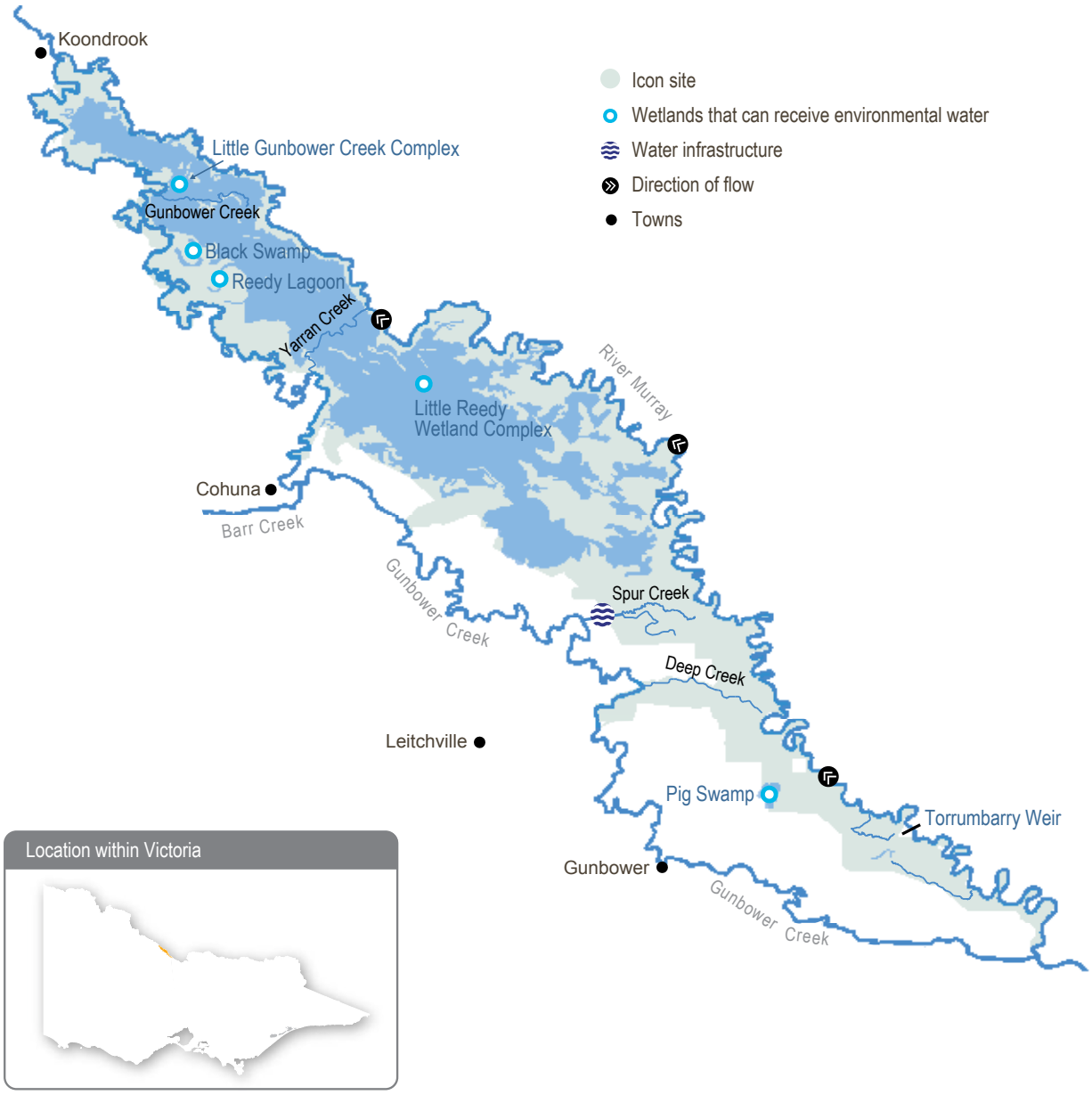
System overview

Gunbower Forest is an internationally significant site under the Ramsar Convention and forms part of the Living Murray Gunbower–Koondrook–Perricoota 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, 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 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 3,800 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).

Figure 5.2.2 Gunbower Creek and Forest



Recent conditions

Monitoring conducted after natural floods in late 2016 detected a large population of carp in Gunbower Forest's wetlands. The carp were damaging wetland vegetation and causing high turbidity. To manage the impact of the carp, the floodplain and wetlands were intentionally left to draw down and dry after the natural inflows in late 2016, with no water for the environment delivered to the forest for the remainder of the 2016–17 year. The North Central CMA used the drying conditions to remove 1,170 kg of carp (mostly large adults) from Reedy Lagoon and Black Swamp.

Water for the environment was used to partially fill Reedy Lagoon and Black Swamp in late spring 2017. In the absence of large-bodied carp, aquatic plants flourished and were able to germinate, establish and set seed. In Reedy Lagoon, the managed delivery triggered a dense cover of vulnerable river swamp wallaby-grass. In Black Swamp, the number and distribution of aquatic plants was the highest on record and several plant species not commonly observed were recorded including river swamp wallaby-grass and wavy marshwort.

High rainfall in early December 2017 increased flows in the River Murray and delivered minor flows through deeper floodrunners and creeks in upper Gunbower Forest. To maintain the carp exclusions, these flows were prevented from connecting to Reedy Lagoon and Black Swamp. In the absence of large-bodied carp, vegetation in both wetlands proliferated over summer and autumn as water levels receded. A small volume of water remains in both wetlands and is expected to persist in deeper areas to the end of 2017–18.

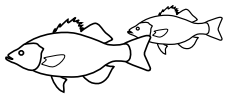
The improved extent and condition of aquatic vegetation in Reedy Lagoon and Black Swamp provided excellent feeding habitat for many waterbirds, including eastern great egrets and white-faced heron. It also provided breeding habitat for Australasian grebes, white-bellied sea eagles and black swans.

The success of environmental watering in Reedy Lagoon and Black Swamp highlights the benefits of coordinating deliveries of water for the environment with other management actions to maximise environmental outcomes. Carp exclusion plots, established by the Living Murray Intervention Monitoring Program in 2014–15, were again monitored in a few of the forest wetlands. These trial plots demonstrate how floodplain vegetation responds at different stages of their wetting and drying cycles in the absence of large-bodied fish (including carp) as well as grazing by waterbirds and marsupials. Plots that excluded carp, waterbirds and kangaroos had more-abundant and more-diverse vegetation than plots that only excluded one species.

In 2017–18, flows in Gunbower Creek allowed large-bodied fish, especially Murray cod, to migrate, spawn, feed and breed. Since implementing managed environmental flows in Gunbower Creek in 2011, the native fish population has steadily increased. Higher flows provided in winter/spring 2017 helped maintain fish nursery habitats, and Gunbower Creek now supports a healthy population of Murray cod of varying ages and greater numbers of golden perch, silver perch and freshwater catfish.

In mid-June 2018, water for the environment was delivered to Gunbower Forest to support river red gums and the flood-dependent understory. The water delivery was timed to maximise deliveries into the forest before irrigation orders (due to resume from 15 August) were to take up much of the capacity of Gunbower Creek. The delivery of environmental water to Gunbower Forest is planned to continue during winter/spring 2018–19.

River swamp wallaby grass at Reedy Lagoon, by North Central CMA



Scope of environmental watering

Table 5.2.4 shows potential environmental watering actions and their environmental objectives.

Table 5.2.4 Potential environmental watering actions and objectives for Gunbower Creek and Forest

Potential environmental watering	Environmental objectives
Gunbower Forest	
Inundation of Gunbower Forest floodplain, floodrunners and wetlands (fill in winter/spring and provide top-ups if a significant bird-breeding event occurs)	• Improve the health of river red gum, black box and grey box communities • Maintain/enhance healthy populations of native fish in wetlands and increase opportunities for riverine fish to access floodplain resources • Maintain suitable feeding, breeding and refuge habitat for waterbirds including colonial nesting species • Support a significant bird-breeding event
Semipermanent and permanent forest wetlands (fill in winter/spring and provide top-ups if a significant bird-breeding event occurs) Reedy Lagoon and Black Swamp (fill in winter/spring and provide top-ups if a significant bird-breeding event occurs)	• Maintain the health and resilience of vegetation communities in permanent wetlands • Maintain suitable feeding and refuge habitat for waterbirds • Support a significant bird-breeding event
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 River Murray through the Yarran Creek and Shillinglaws regulators, to increase flowing habitat for the lateral movement of native fish, turtles and seed propagules • Provide migration and spawning opportunities for native fish
Extend natural flooding in Gunbower Forest floodplain, floodrunners and wetlands (with variable flow rates to maintain appropriate inundation extent)	• Improve the health of river red gum communities • Maintain/enhance healthy populations of native fish in wetlands and increase opportunities for riverine fish to access floodplain resources • Maintain suitable feeding, breeding and refuge habitat for waterbirds including colonial nesting species • Support a significant bird-breeding event
Reedy Lagoon and Black Swamp (top-ups in autumn/winter)	• Maintain/enhance the health and resilience of vegetation communities in permanent wetlands • Maintain suitable feeding, breeding and refuge habitat for waterbirds including colonial nesting species
Inundation of Gunbower Forest floodplain, floodrunners and wetlands (fill in autumn/winter 2019)	• Improve the health of river red gum, black box and grey box communities • Maintain/enhance healthy populations of native fish in wetlands and increase opportunities for riverine fish to access floodplain resources • Maintain suitable feeding, breeding and refuge habitat for waterbirds including colonial nesting species
Gunbower Creek	
Winter low flows (up to 400 ML/day between May–August)	• Increase the survival and maintain the growth of native fish (such as Murray cod) by maintaining access to food and habitat resources
Spring/summer high flows (targeting a gradual increase in flows up to 650 ML/day including various periods of stable flows in August–January)	• Increase the recruitment, growth and survival of native fish (such as Murray cod) by maintaining access to breeding habitat and food resources
Year-round low flows (above 400 ML/day between August–May)	• Maintain native fish survival and growth by increasing access to habitat and food resources

Table 5.2.4 Potential environmental watering actions and objectives for Gunbower Creek and Forest *continued*

Potential environmental watering	Environmental objectives
Summer/autumn low flows (above 300 ML/day, between January–May)	• Maintain native fish survival and growth by increasing access to habitat and food resources
Increased low flows (up to 550 ML/day year-round if unregulated conditions occur in the River Murray)[1]	• Increase native fish recruitment by providing cues for migration and spawning, in line with larger flows in the River Murray • Increase the growth and survival of native fish (such as Murray cod) by maintaining access to breeding habitat and food resources
Spring/summer/autumn freshes (up to 550 ML/day between October-April)[1]	• Increase native fish recruitment from the River Murray populations into the Creek by providing cues for migration and spawning, in line with larger flows in the River Murray • Maintain water quality below Koondrook Weir to dilute low-dissolved-oxygen water that may exit Gunbower Forest

[1] *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 5.2.5 outlines the potential environmental watering and expected water use under a range of planning scenarios.

Floodplain watering of Gunbower Forest started in June 2018 and needs to continue into 2018–19 to meet target inundation levels. Continuation of that watering event is therefore the highest priority in all climate scenarios. The main objective for this event is to inundate the floodplain, floodrunners and wetlands in Gunbower Forest during winter/spring 2018, to support the flood-dependent understorey and continue the recovery of wetland plant communities since the Millennium Drought. Water for the environment can inundate about 16 percent of Gunbower Forest, and this area has received either natural or managed flows in five of the last 10 years. Water delivered in 2018–19 will improve and protect the health of river red gums higher on the floodplain that have not received water since the natural floods in 2016.

Managed flows to Gunbower Forest will maintain water levels in wetlands to ensure the wetland vegetation remains in good condition and to increase the success of any significant colonial waterbird-breeding event that may be triggered by managed flows. If bird breeding occurs, water for the environment will be used to maintain an adequate water depth at selected wetlands until juvenile birds are successfully fledged or the breeding event fails due to other factors.

In wetter scenarios, when flows in the River Murray exceed 15,000 ML per day in winter/spring for more than two weeks, 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.

Flows above 20,000 ML per day in the River Murray will force water into the forest. If natural flooding occurs during or before planned deliveries of water for the environment, the managed inflows may be cancelled, suspended or reduced. Water for the environment may be delivered at the end of a natural flood to extend the duration or extent of inundation throughout the forest, to increase ecological outcomes.

In a dry to wet scenario, water for the environment may be used to inundate the river red gum floodplain for a second time in autumn/winter 2019. This water delivery will build on the vegetation outcomes of the winter/spring 2018 event and improve the condition of river red gums in the forest.

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.

In all climate scenarios, 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. 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, unregulated flows may trigger the use of additional water for the environment to provide short freshes or increased low flows in Gunbower Creek. Increased 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.

In 2018–19, the planned delivery to Gunbower Forest will reduce the capacity to deliver the full range of flows for large-bodied fish in Gunbower Creek. Flows will be managed to maintain flowing habitat to support the existing native fish population. A fresh may be delivered downstream of Koondrook Weir to dilute low-dissolved-oxygen water, if flows exit the forest during or after the floodplain watering action.

Table 5.2.5 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]	• Inundation of Gunbower Forest floodplain, floodrunners and wetlands (winter/ spring) • Semipermanent and permanent forest wetlands (winter/spring) • Gunbower Creek winter low flows • Gunbower Creek spring/summer/ autumn low flows	• Inundation of Gunbower Forest floodplain, floodrunners and wetlands (winter/ spring) • Semipermanent and permanent forest wetlands (winter/spring) • Gunbower Creek winter low flows • Gunbower Creek spring/summer/ autumn low flows	• Inundation of Gunbower Forest floodplain, floodrunners and wetlands (winter/ spring) • Semipermanent and permanent forest wetlands (winter/spring) • Gunbower Creek winter low flows • Gunbower Creek spring/summer/ autumn low flows • Yarran Creek winter/spring fresh	• Inundation of Gunbower Forest floodplain, floodrunners and wetlands (winter/ spring) • Semipermanent and permanent forest wetlands (winter/spring) • Gunbower Creek winter low flows • Gunbower Creek spring/summer/ autumn low flows • Yarran Creek winter/spring fresh
Potential environmental watering – tier 2 (additional priorities)	• Yarran Creek winter/spring fresh • Reedy Lagoon and Black Swamp (autumn/winter)	• Yarran Creek winter/spring fresh • Inundation of Gunbower Forest floodplain, floodrunners and wetlands (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 • Inundation of Gunbower Forest floodplain, floodrunners and wetlands (autumn/ winter)
Possible volume of water for the environment required to meet objectives[2,3]	• 87,100 ML (tier 1) • 4,500 ML (tier 2)	• 87,100 ML (tier 1) • 38,250 ML (tier 2)	• 88,600 ML (tier 1) • 36,750 ML (tier 2)	• 88,600 ML (tier 1) • 39,750 ML (tier 2)
Priority carryover requirements	• 74,100 ML	• 74,100 ML	• 74,100 ML	• 74,100 ML

[1] *In dry to average planning scenarios, an addition 2,000 ML has been included to support a significant bird-breeding event that may be triggered by Gunbower floodplain inundation, under tier 1 actions.*

[2] *Represents the estimated volume of water required to underwrite the losses associated with the delivery of consumptive water en route (except for discrete wetland watering actions) in Gunbower Creek and Gunbower Forest.*

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

Risk management

Environmental watering program partners have considered and assessed risks and identified mitigating strategies relating to environmental flows in 2018–19. Risks and mitigating actions are continually reassessed by program partners throughout the water year (see section 1.3.6).

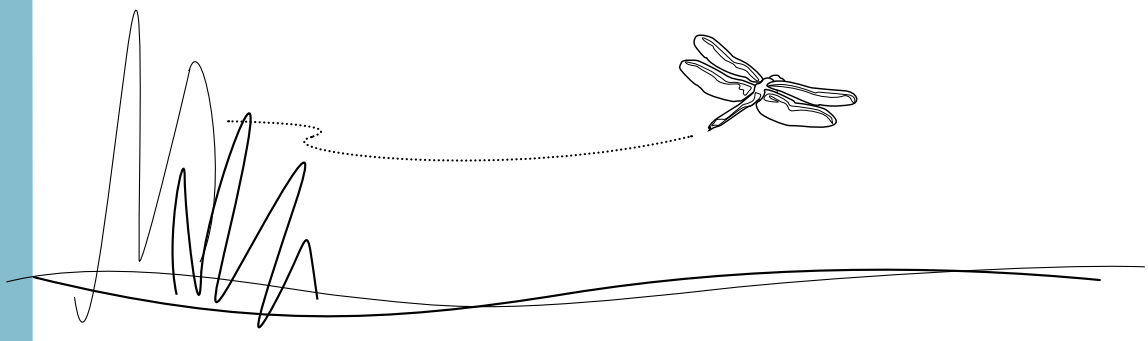
Engagement

Table 5.2.6 shows the partners and stakeholder organisations with which North Central CMA engaged when preparing the Gunbower Creek and Forest seasonal watering proposal.

Seasonal watering proposals are informed by longer-term regional catchment strategies, regional waterway strategies, environmental flow studies, water management plans and other studies. These incorporate a range of environmental, cultural, social and economic perspectives and longer-term integrated catchment and waterway management objectives. For further details, refer to the *North Central Regional Catchment Strategy* and *North Central Waterway Strategy*.

Table 5.2.6 Partners and stakeholders engaged in developing the Gunbower Creek and Forest seasonal watering proposal

Partner and stakeholder engagement
• Gannawarra Shire Council, Campaspe Shire Council and Cohuna Progress Association • Gunbower Island Community Reference Group (with representation from the Cohuna Progress Association, bird observers, Field & Game Australia, BirdLife Australia, Gunbower Landcare Group, irrigators and general community members) • Gunbower Operations Advisory Group (with representation from Goulburn-Murray Water, Parks Victoria, Department of Environment, Land, Water and Planning, Vic Forests, State Forests NSW, North Central CMA, Murray–Darling Basin Authority, Commonwealth Environmental Water Holder and the Victorian Environmental Water Holder • Gunbower Technical Working Group (with representatives of Department of Environment, Land, Water and Planning [Threatened Flora and Fauna]; and specialist fish, vegetation and bird consultants and ecologists) • Yorta Yorta Nation Aboriginal Corporation and Barapa Barapa Nations Traditional Owners



5.2.3 Central Murray wetlands

The central Murray wetlands are located on the lower Loddon River and River Murray floodplains (Figure 5.2.3). The wetland system consists of 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.

Wetlands in this region continue to be important places for Traditional Owners and their Nations. The Registered Aboriginal Party (RAP) in the region is the Yorta Yorta Nation Aboriginal Corporation. Representatives from Barapa Barapa and Wamba Wemba Nations' Traditional Owners were engaged during the development of seasonal watering proposals to propose environmental watering actions that would support culturally significant wetland plants in Guttrum Forest. Those proposals have been incorporated in this seasonal watering plan. Traditional Owners in the region have an ongoing connection to the central Murray wetlands.

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 bird species (including the great egret and white-bellied sea eagle) listed under legislation and international agreements. There are internationally recognised, Ramsar-listed wetlands in the system including Lake Cullen, Hird Swamp and Johnson Swamp, while the other wetlands in the central Murray system have bioregional significance.

Social and economic values

The central Murray wetlands are used for recreational activities including birdwatching and bushwalking; some wetlands are also used for duck hunting. Tourism to the region supports the local economy. Other indirect economic benefits associated with the wetlands include groundwater recharge and carbon storage.

Environmental watering objectives in the central Murray wetlands

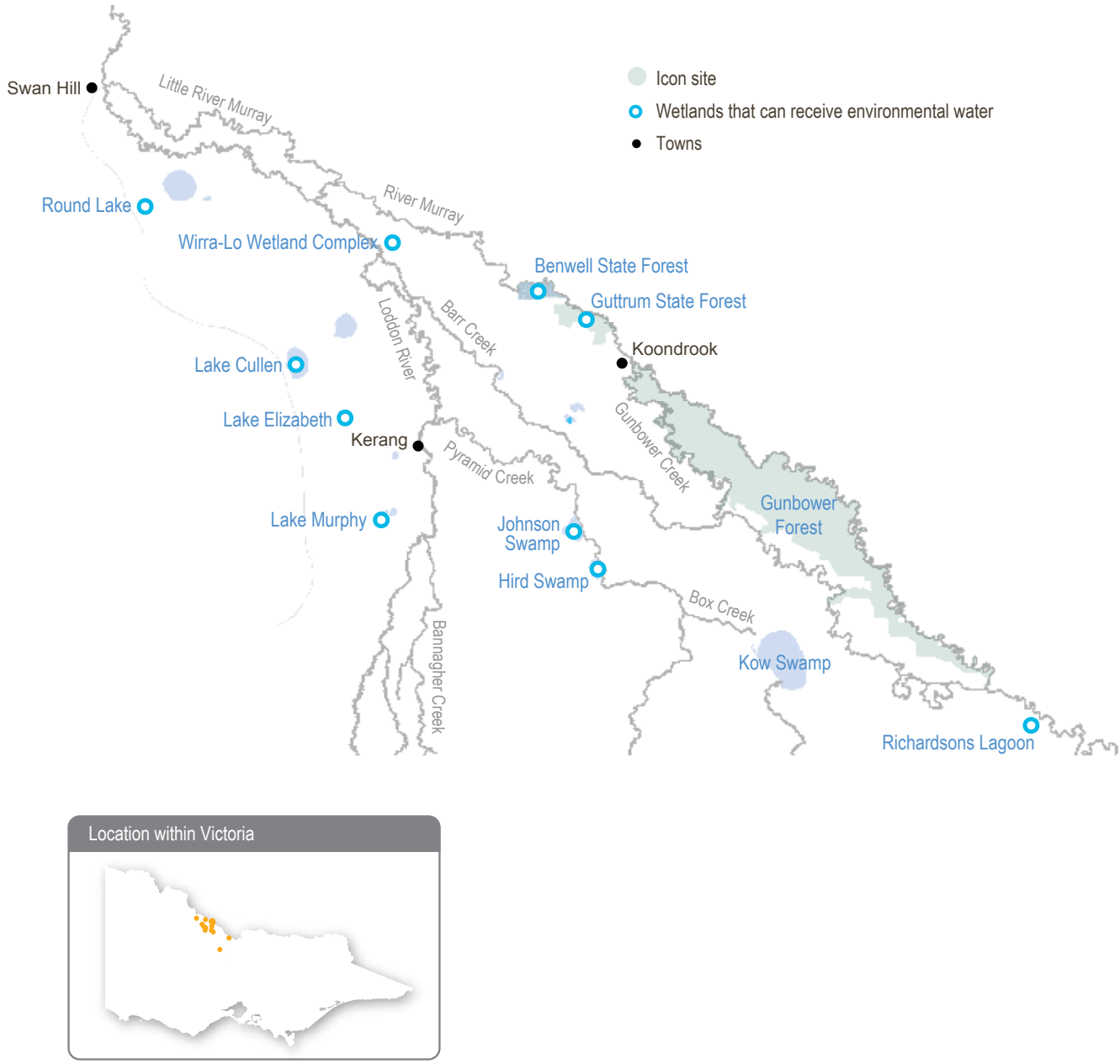
	Maintain and rehabilitate river red gum, black box, lignum woodland and wetland plant communities Provide appropriate wetting and drying conditions that support seed germination, seedling survival and recruitment including of semiaquatic plant species in damp areas of wetlands Manage the extent and density of invasive plant species including tall marsh vegetation Support a mosaic of wetland plant communities to provide feeding and breeding habitat for native fauna
	Maintain habitat for the critically endangered Murray hardyhead
	Provide habitat for waterbird resting, feeding and breeding including for threatened species (such as Australasian bittern, little bittern and brolga)
	Provide habitat for the endangered growling grass frog

System overview

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 very rarely flood naturally. 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. To date, neither Guttrum or Benwell forests, which border the River Murray, have permanent infrastructure to deliver environmental water. Temporary pumps may be used to deliver water for the environment from the River Murray to some semipermanent wetlands in the Guttrum and Benwell forests.

Figure 5.2.3 Central Murray wetlands



Recent conditions

Higher-than-average rainfall at the start of the 2017–18 water year saw the Murray system seasonal determination rise from an opening 66 percent to 100 percent high-reliability water shares by October 2017. Despite high rainfall in November and December 2017, natural inflows to the central Murray wetlands were limited by artificial barriers (such as channels, roads and levees). Water for the environment was therefore the primary source of water for most wetlands in the region. Water for the environment was delivered to seven of the central Murray wetlands in 2017–18.

In Round Lake and Lake Elizabeth, water for the environment was used to periodically top-up water levels to maintain suitable water-quality conditions for endangered Murray hardyhead. Round Lake maintains a stable population of Murray hardyhead. Recent monitoring undertaken as part of the statewide Wetland Monitoring and Assessment Program (WetMAP) for environmental watering detected more than 20 Murray hardyhead at Lake Elizabeth, which indicates that the translocation of Murray hardyhead in 2016 was successful; and there is evidence of subsequent recruitment. This is an extremely positive result for the site, as it only started receiving water for the environment in 2014.

Water for the environment was used to support waterbirds, plants and other animals typical of temporary freshwater marshes at Richardsons Lagoon, Wirra-Lo wetland complex, Hird Swamp, McDonalds Swamp and Lake Murphy.

The filling of Richardsons Lagoon marked the completion of the three-year watering cycle recommended in the Richardsons Lagoon Environmental Water Management Plan. Waterbird monitoring has demonstrated that the lagoon and its surrounding woodland support up to 52 bird species including 28 waterbird species. The number of bird species recorded at Richardsons Lagoon in 2017–18 was slightly higher than in recent wet years. Observations of juvenile black swans and nankeen night herons suggests there has been successful bird breeding at the wetland. Richardsons Lagoon will be allowed to draw down and dry over about three years, before it is due to receive more environmental water.

Delivery of water for the environment to Wirra-Lo wetland complex at Duck Creek North and Duck Creek South in spring/summer 2017 aimed to provide refuge habitat and suitable breeding conditions for the nationally-endangered growling grass frog as well as create high-quality feeding and breeding habitat for waterbirds. Growling grass frogs were heard calling at Wirra-Lo wetland complex in summer 2017–18, and this is the first record of growling grass frogs on the Murrabit West floodplain since 2008. The return of the growling grass frog to Wirra-Lo wetland complex within four years of rehabilitation works demonstrates the benefits of providing water for the environment.

Water for the environment supported large numbers of waterbirds at Hird Swamp in 2017–18. Regular monitoring consistently recorded about 40 waterbird species at Hird Swamp between October and December 2017. The greatest abundance of waterbirds recorded in a single survey at Hird Swamp was 2,743 individuals in November including 600 Australasian grebes. Many threatened species were recorded at Hird Swamp in 2017–18 including Baillon's crake, whiskered tern, glossy ibis, royal spoonbill, eastern great egret, Australasian bittern, Australasian little bittern, magpie goose, white-bellied sea eagle, musk duck and nankeen night heron. There was also evidence of bird breeding at Hird Swamp in spring and summer 2017–18 as juvenile waterbirds from various species including black swan, banded rail and brown quail were recorded. A brolga nest with two eggs was discovered in early February 2018, but these were later reported missing, likely due to predation.

No water for the environment was delivered to Johnson Swamp, Lake Cullen or Guttrum and Benwell forests in 2017–18. Johnson Swamp and Lake Cullen were managed for drying and drawing down respectively. Some parts of the Guttrum and Benwell forests received natural inflows during early summer 2017 from high flows in the River Murray. However, most of the forest understorey and wetlands remain in poor condition. The forests require a more-natural watering regime to support recovery from the Millennium Drought and historical grazing pressure.

Scope of environmental watering

Table 5.2.7 shows potential environmental watering actions (including wetland drying) and their environmental objectives.

Spoonbill in flight over Hird Swamp at sunrise, by Zarleen Blakeley

Table 5.2.7 Potential environmental watering actions and objectives for central Murray wetlands

Potential environmental watering	Environmental objectives
Wetland watering	
Guttrum and Benwell forests (fill Reed Bed Swamp and Little Reed Bed Swamp in winter/spring and autumn/winter, top-ups to support bird breeding)[1]	• Rehabilitate aquatic vegetation, semiaquatic vegetation and river red gum communities in semipermanent wetlands • Provide feeding, breeding and refuge habitat for waterbirds, frogs and turtles • Support colonial waterbird breeding, if it occurs
Johnson Swamp (fill in spring)	• Provide feeding and breeding habitats for waterbirds • Minimise the growth of tall marsh vegetation
Lake Cullen (spring fill)	• Support waterbird populations by providing suitable roosting and feeding habitat • Increase the growth and recruitment of aquatic vegetation
Lake Elizabeth (top-ups as required to maintain water-quality targets)	• Maintain habitat for translocated Murray hardyhead • Support submerged salt-tolerant aquatic plant assemblage and a high diversity of waterbirds
Lake Murphy (partial fill in autumn/winter)	• Promote the growth of a variety of vegetation communities (including recently planted juvenile river red gums) to support waterbird and frog feeding and breeding habitats
McDonalds Swamp (fill in spring and provide top-ups if required to support bird breeding)	• Increase the variety of vegetation communities by supporting the survival and growth of juvenile river red gums and reducing the spread of tall marsh • Facilitate early plant germination and provide suitable conditions for winter frog breeding
Round Lake (top-ups as required to maintain water-quality targets)	• Maintain habitat for Murray hardyhead • Maintain suitable waterbird habitat
Wirra-Lo wetland complex (top-ups as required to support a mosaic of wet and dry habitat)	• Rehabilitate river red gum and a variety of aquatic vegetation communities, providing suitable habitat for the growling grass frog and a high diversity of waterbirds including brolga • Provide habitat for water-dependent animals
Wetland drying	
Hird Swamp, Richardsons Lagoon	• Not to be actively watered in 2018–19 • Seasonal drying helps to maintain the health of existing trees in the bed of the wetlands • The drying phase of Hird Swamp will help to manage tall reed vegetation and promote herbland species

[1] *Infrastructure projects for Guttrum and Benwell forests are being assessed as part of the Sustainable Diversion Limit Offset component of the Basin Plan. Until works are approved and completed, only semipermanent wetlands that can receive water pumped from the River Murray will be considered for watering.*

Scenario planning

Table 5.2.8 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 wetlands of highest priority (tier 1) for management of water for the environment in the central Murray wetlands in 2018–19 under all planning scenarios are Round Lake, Lake Elizabeth and the Wirra-Lo wetland complex. Round Lake supports what is considered to be the only stable population of the critically endangered Murray hardyhead in the Kerang area, and it is used to stock hardyhead in other wetlands across Victoria including Lake Elizabeth. The Wirra-Lo wetland complex is a permanent drought refuge for waterbirds and other threatened species (such as the nationally listed growling grass frog).

The Guttrum and Benwell forests have not received water for the environment to date and have only received natural inflows in five of the past 10 years. The forests are still recovering from the Millennium Drought and grazing pressures in previous years, and they need more-frequent inundation. Providing water for the environment in line with a more-natural flooding regime in winter/spring 2018 is also a high priority for 2018–19 in all scenarios, to rehabilitate the wetland plants and river red gum forest in Reed Bed Swamp and Little Reed Bed Swamp. The delivery of water for the environment will also provide an opportunity to collect hydrological and hydraulic information to inform the design of future, permanent infrastructure projects.

If water availability increases under all planning scenarios, water for the environment may be delivered to additional wetlands or for additional watering actions (under tier 2) to help meet native plant, animal and waterbird objectives. Under drought and dry conditions, water for the environment may be used to fill some wetlands that did not receive water for the environment or natural inflows in 2017–18, or to maintain water depth in wetlands that received water for the environment in the previous year.

Under very wet conditions, large floods may partially or completely fill some of the central Murray wetlands, but water for the environment may be required to maintain water depth to support waterbird breeding and vegetation condition.

Lake Cullen may receive a top-up in spring 2018, depending on the outcomes of an investigation into groundwater interactions between the lake and the neighbouring Avoca Marshes. Top-ups to the lake will provide important refuge for waterbirds to rest and feed.

Johnson Swamp is scheduled to receive a fill in spring, if there is enough environmental allocation. Johnson Swamp has dried over the last two and a half years, and watering in spring aims to provide feeding and breeding opportunities for waterbirds. Some flows will also be managed through Johnson Swamp, with outflows of carbon-rich water being delivered to Pyramid Creek during a planned spring fresh. These through-flows aim to boost the carbon supply to Pyramid Creek and increase the productivity of the riverine foodweb. They are good examples of how water for the environment is used to support fundamental ecological processes and maximise ecological outcomes across multiple waterways.

No water for the environment is planned for delivery to Hird Swamp or Richardsons Lagoon. These wetlands are planned to undergo a drying phase to promote the growth of herbland species and fringing vegetation.

Table 5.2.8 Potential environmental watering for 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 wetlands 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 in winter/spring
Potential environmental watering – tier 1 (high priorities)	• Round Lake • Lake Elizabeth • Wirra-Lo wetland complex • Guttrum and Benwell forests (winter/spring)	• Round Lake • Lake Elizabeth • Wirra-Lo wetland complex • Guttrum and Benwell forests (winter/spring) • Lake Cullen[1] • McDonalds Swamp • Lake Murphy	• Round Lake • Lake Elizabeth • Wirra-Lo wetland complex • Guttrum and Benwell forests (winter/spring) • Lake Cullen[1] • McDonalds Swamp • Lake Murphy • Johnson Swamp	• Round Lake • Lake Elizabeth • Wirra-Lo wetland complex • Guttrum and Benwell forests[3] • Lake Cullen[1] • McDonalds Swamp • Lake Murphy • Johnson Swamp
Potential environmental watering – tier 2 (additional priorities)	• McDonalds Swamp • Lake Murphy	• Johnson Swamp • Guttrum and Benwell forests (autumn/winter)	• Johnson Swamp • Guttrum and Benwell forests (autumn/winter)	• N/A
Possible volume of water for the environment required to meet objectives[2]	• 14,900ML (tier 1) • 6,600 ML (tier 2)	• 18,000 ML (tier 1) • 4,500 ML (tier 2)	• 21,500 ML (tier 1) • 700 ML (tier 2)	• 21,100 ML (tier 1)[3]
Priority carryover requirements	• 3,700 ML	• 2,900 ML	• 2,900 ML	• 2,300 ML

1 *Dependent on the outcomes of the Lake Cullen groundwater investigation.*

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

3 *Natural inflows may fill Guttrum and Benwell forests in a wet scenario; and if a significant bird-breeding event is triggered, water for the environment may be pumped to the wetlands if appropriate.*

Risk management

Environmental watering program partners have considered and assessed risks and identified mitigating strategies relating to environmental flows in 2018–19. Risks and mitigating actions are continually reassessed by program partners throughout the water year (see section 1.3.6).

Engagement

Table 5.2.9 shows the partners, stakeholder organisations and individuals with which North Central CMA engaged when preparing the central Murray wetlands seasonal watering proposal.

Seasonal watering proposals are informed by longer-term regional catchment strategies, regional waterway strategies, environmental flow studies, water management plans and other studies. These incorporate a range of environmental, cultural, social and economic perspectives and longer-term integrated catchment and waterway management objectives. For further details, refer to the *North Central Regional Catchment Strategy* and the North Central Waterway Strategy.

Table 5.2.9 Partners and stakeholders engaged in developing the central Murray wetlands seasonal watering proposal

Partner and stakeholder engagement
• Barapa Barapa Nations Traditional Owners • Birdlife Australia • Central Murray Wetlands Environmental Water Advisory Group (made up of community members, private landholders, interest groups including Game Management Authority, North Central CMA project staff and Board representation) • Commonwealth Environmental Water Office • Community members • Department of Environment, Land, Water and Planning • Field & Game Australia • Gannawarra Shire Council • Goulburn-Murray Water • Gunbower Operations Advisory Group (with representation from Goulburn-Murray Water, Parks Victoria, Department of Environment, Land, Water and Planning, Vic Forests, State Forests NSW, North Central CMA, Murray–Darling Basin Authority, Commonwealth Environmental Water Holder and the Victorian Environmental Water Holder) • Landholders owning a wetland that receives environmental water • Loddon Shire Council • North Central CMA Board • Parks Victoria • Swan Hill Rural City Council • Victorian Environmental Water Holder • Wamba Wemba Nations Traditional Owners

5.2.4 Hattah Lakes

Hattah-Kulkyne National Park is situated in north-western Victoria adjacent to the River Murray (Figure 5.2.4) The national park contains a complex of more than 20 semipermanent freshwater lakes known collectively as Hattah Lakes. The ecology of the lakes and floodplain is strongly influenced by flooding regimes of the River Murray. The construction of a permanent pump station, regulators and levees at Hattah Lakes in 2013 has enabled greater volumes of water for the environment to be delivered to the site, to return a more-natural, healthy pattern of flooding to the lakes.

Hattah Lakes is an important place for Traditional Owners and their Nations. Currently there is no Registered Aboriginal Party for the region and the Mallee CMA involves the region's Traditional Owners in the management of Hattah Lakes through its Aboriginal Reference Group, which includes First Peoples of the Millewa-Mallee and the Wadi Wadi and Tati Tati Traditional Owners.

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 every four to five years. Regulation of the River Murray has resulted in less-frequent floods of shorter duration, and many of the vegetation communities across the site do not receive enough water without the delivery of environmental water. A combination of natural flooding and delivery of water for the environment since 2010 has improved canopy health and recruitment of black box communities.

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 habitat for native fish and terrestrial animals. The endangered freshwater catfish is known to inhabit the lakes.

Social and economic values

Hattah-Kulkyne National Park is a popular location for camping, canoeing, birdwatching and photography. Local businesses in the area benefit from increased visitation following environmental watering and natural flooding events.

Environmental watering objectives in the Hattah Lakes

	Rehabilitate a healthy and diverse mix of wetland and floodplain plant life to maintain the ecological character of this internationally protected site
	Provide feeding and breeding habitat for a range of waterbird species including threatened and migratory species and colonial nesting species (such as the spoonbill and egret)

System overview

The Hattah Lakes system is filled when there are high flows in the River Murray, and some lakes hold water for several years after flood waters recede. Regulation of the River Murray has significantly reduced the frequency and magnitude of 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.

Large-scale engineering works were completed under the Living Murray program to allow water regimes in Hattah Lakes to be more effectively managed over a range of River Murray flows. Those works include building a permanent pump station and levees that allow water to be pumped from the River Murray to the Hattah Lakes via Chalka Creek. Regulators were also built and are operated to retain water in the lakes and then release it at specific times and rates to support the environmental values of the system.

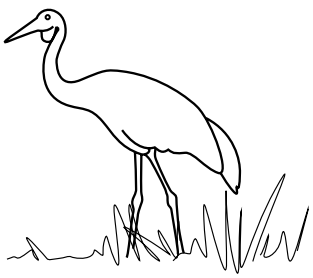
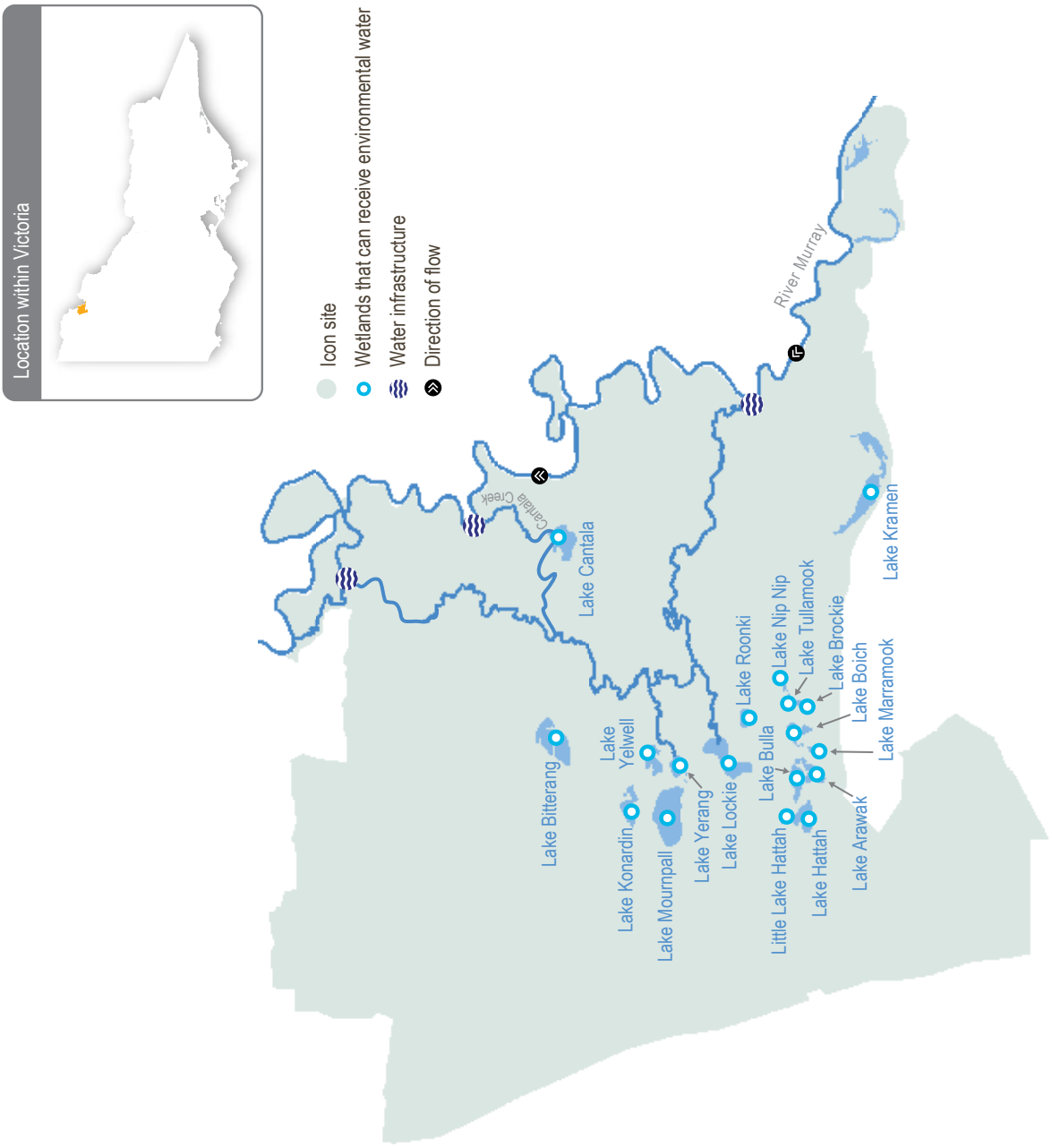


Figure 5.2.4 Hattah Lakes



Recent conditions

Environmental watering in 2017–18 aimed to improve the health of black box woodland on the Hattah Lakes floodplain and to consolidate some of the ecological outcomes that were triggered by natural floods in spring 2016.

Looking back two years to July 2016, it was not anticipated that any water for the environment would be provided to Hattah Lakes. The seasonal outlook was dry and some of the lower-lying lakes had received water three times in the previous four years, so wetland drying was considered appropriate to draw down lake levels to allow seeds to germinate and plants to establish themselves on the edges of the wetland.

Winter and spring 2016 were wetter than expected, so a decision was made to deliver water for the environment to Hattah Lakes during September and October 2016 to align with the wet conditions. Late October and November 2016 brought the largest floods in the River Murray in the last two decades. The Hattah Lakes and floodplain were inundated for 16 consecutive weeks and reached a maximum level of 44.6 m AHD (Australian Height Datum), providing perfect conditions for the recovery of black box trees that had not been flooded since the 1990s.

The ecological productivity boost and increase in new plant growth associated with floods can be short-lived without significant watering in the subsequent year. Over 110 GL of water for the environment was delivered to the Hattah Lakes between July and October 2017 to support the further germination, growth and recovery of black box trees. The water delivery aimed to inundate as much of the Hattah Lakes as possible within the constraints of the available infrastructure. Water levels throughout the lakes reached 44.85 m AHD, which is the highest inundation by environmental or flood water since the 1970s. Recent monitoring indicates that black box health has improved, with tree canopy cover increasing in areas that received water for the environment in 2017–18.

Scope of environmental watering

Table 5.2.10 shows potential environmental watering actions and their environmental objectives.

Table 5.2.10 Potential environmental watering actions and objectives for the Hattah Lakes

Potential environmental watering[1]	Environmental objectives
Wetland watering	
Natural inundation of Chalka Creek and Hattah Lakes	• Allow natural connectivity between Hattah Lakes and the River Murray • Allow exchange of carbon, nutrients and biota between the wetlands and the River Murray
Wetland drying	
Drying of Hattah Lakes	• Maintain the lake bed herbland as water levels recede • Allow drying of lakes to manage carp and improve wetland condition

[1] *The Hattah Lakes pump station may also be operated at any time of year to meet annual maintenance requirements.*

Scenario planning

Table 5.2.11 outlines potential environmental watering and expected water use under a range of planning scenarios.

The Hattah Lakes have received water for the environment in every year since 2012–13, so the priority in 2018–19 will be to allow the lakes and surrounding floodplain to naturally dry. Watering requirements for woodlands and semipermanent wetlands have been met and these communities now need time to dry and allow new understory to develop. Widespread drawdowns in lake water levels will enable seeds to germinate and plants to grow and become established in the littoral zone. Exposed mudflats and shallow-water habitats established by drying will provide feeding habitat for waterbirds. Drying the lakes will also help to manage non-native fish species (such as carp), which threaten the environmental values of the site.

No delivery of water for the environment is planned for 2018–19, but the regulator gates will remain open to allow any natural floods to enter and leave the floodplain, allowing connectivity between the lakes and river for the exchange of carbon, nutrients and biota. The Hattah Lakes pump station may need to use some water for the environment for annual maintenance, testing and commissioning of updated infrastructure. A contingency of 4,000 ML has been set aside for that purpose.

Table 5.2.11 Potential environmental watering for the Hattah Lakes under a range of planning scenarios

Planning scenario	Drought	Dry	Near-average	Very wet
Expected 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	• Wetland drying	• Wetland drying	• Wetland drying with some minor, natural inflows	• Natural inundation of Chalka Creek and Hattah Lakes
Possible volume	• 0 ML	• 0 ML	• 0 ML	• 0 ML

Risk management

Environmental watering program partners have considered and assessed risks and identified mitigating strategies relating to environmental flows in 2018–19. Risks and mitigating actions are continually reassessed by program partners throughout the water year (see section 1.3.6).

Engagement

Table 5.2.12 shows the partners and stakeholder organisations who have assisted the Mallee CMA prepare the Hattah Lakes seasonal watering proposal.

Seasonal watering proposals are informed by longer-term regional catchment strategies, regional waterway strategies, environmental flow studies, water management plans and other studies. These incorporate a range of environmental, cultural, social and economic perspectives and longer-term integrated catchment and waterway management objectives. For further details, refer to the *Mallee Regional Catchment Strategy* and the *Mallee Waterway Strategy*.

Table 5.2.12 Partners and stakeholders engaged in developing the Hattah Lakes seasonal watering proposal

Partner and stakeholder engagement
• Birdlife Australia (Mildura)
• Commonwealth Environmental Water Office
• Department of Environment, Land, Water and Planning
• Goulburn-Murray Water
• Landcare Groups (Kulkyne Way Landcare, Red Cliffs and District Landcare, Annuello [Robinvale and District] Landcare, Robinvale Indigenous Landcare, Sea Lake Landcare and Manangatang Landcare)
• Mallee CMA Aboriginal Reference Group including First Peoples of the Millewa-Mallee and members of the Wadi Wadi and Tati Tati Traditional Owners groups
• Mallee CMA Water Technical Advisory Committee (an advisory group to Mallee CMA comprising community members)
• Mid-Murray Field Naturalists
• Mildura Rural City Council
• Mildura 4WD Inc.
• Murray–Darling Basin Authority
• Parks Victoria
• Sunraysia bushwalkers
• Sustainable Living Mildura
• Victorian Environmental Water Holder
• Wildside Outdoors

5.2.5 Lower Murray wetlands

The lower Murray wetlands are found across the floodplain of the River Murray between Swan Hill and the South Australian border (Figure 5.2.5. 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 undefined, 66 of them are considered in the environmental watering program, and 54 of these have received water for the environment to date.

The wetlands of the lower Murray wetlands system hold significance for Traditional Owners and their Nations. For thousands of years, the wetlands provided resources (such as food and materials) to the Latji Latji, Wadi Wadi, Dadi Dadi and Wamba Wemba people. There is currently no Registered Aboriginal Party for the lower Murray wetlands. The Mallee CMA involves the region's Aboriginal communities in water management through the Aboriginal Reference Group, which includes First Peoples of the Millewa-Mallee, Wadi Wadi and Tati Tati Traditional Owners groups.

Cowanna and Brickworks billabongs are nationally significant wetlands located at Merbein Common, next to the River Murray near Mildura. Merbein Common has been identified as a priority for investment under *Water for Victoria*. Investment to improve walking, cycling and canoeing facilities at Merbein Common complements the success of providing environmental flows at Cowanna and Brickworks billabongs.

Environmental values

The lower Murray wetlands are comprised of multiple wetlands, creeks and billabongs on the floodplain of the River Murray. 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 provide important habitat and 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 aerate and oxygen is replaced, and terrestrial plants grow and complete life cycles.

Social and economic values

There are several irrigation districts in the Sunraysia area that are supplied by the River Murray and contribute significant wealth to the local economy. Camping, fishing and other water-based recreational activities are popular along the River Murray including at some wetlands in the lower Murray system. Waterbirds attract birdwatchers throughout the year and duck hunting is allowed during declared seasons.

Environmental watering objectives in the lower Murray wetlands

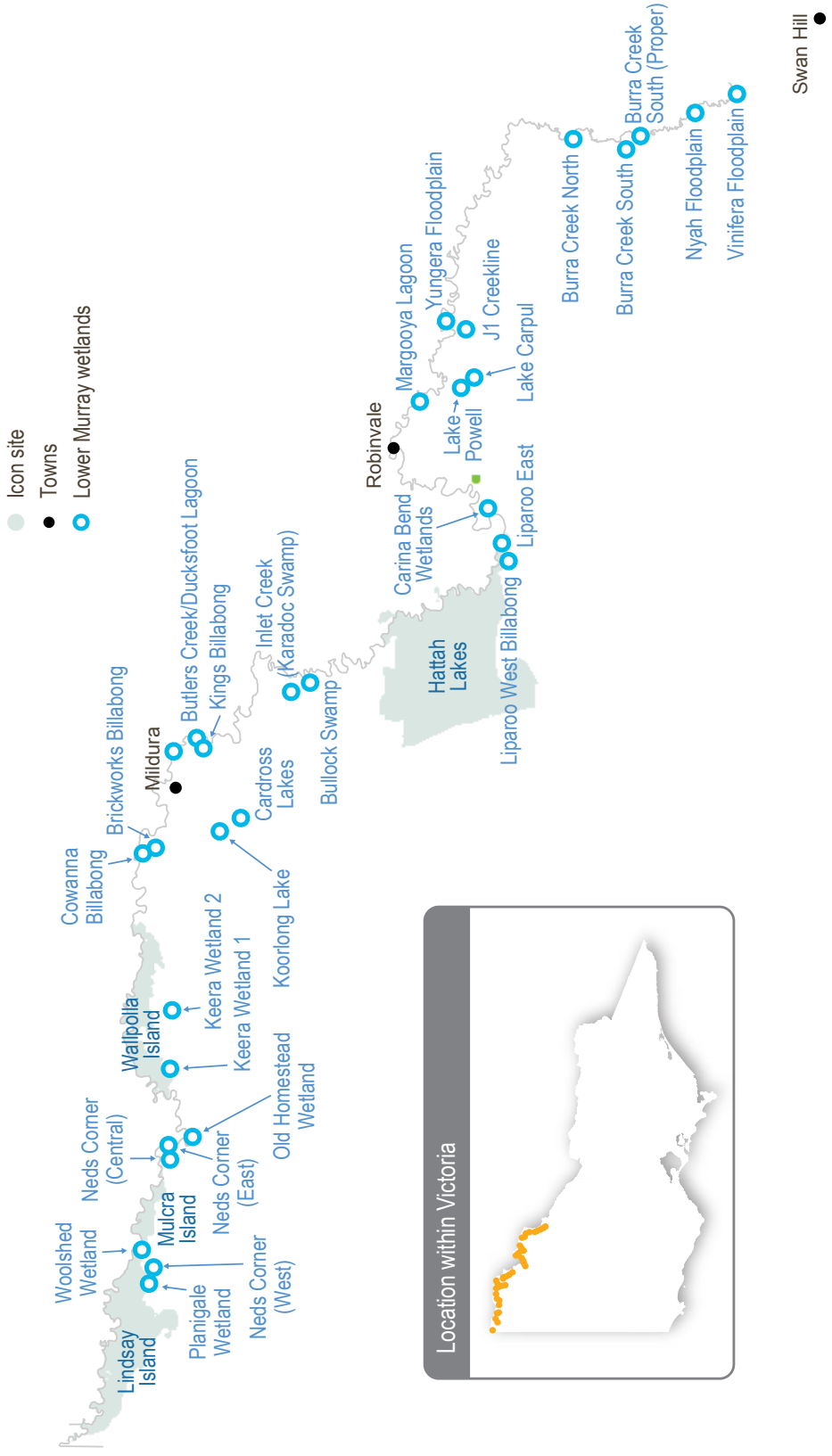
	Increase the diversity, extent and abundance of wetland plants
	Improve the condition of river red gums, black box and lignum to provide habitat for large terrestrial animals (such as lace monitors and bats)
	Provide feeding and breeding habitat for a range of waterbird species including threatened and migratory species and colonial species (such as egrets)
	Improve water quality and increase habitat for fish

System overview

Regulation and diversion of River Murray flows has substantially reduced the frequency and duration of the high river flows that are needed to provide water to the lower Murray wetlands. This change to the water regime has caused a decline in the environmental values associated with billabongs and other floodplain habitats.

Water for the environment can be delivered to some wetlands in the region through a combination of direct pumping from the River Murray and use of irrigation supply infrastructure. Most wetlands that receive water for the environment can be managed independently of each other.

Figure 5.2.5 Lower Murray wetlands



Recent conditions

Apart from a storm-driven flow pulse in early December 2017, the River Murray had lower-than-average inflows for much of 2017–18. Water for the environment was delivered to 11 wetlands in the lower Murray system during the year. Most of this water was used to partially or completely fill wetlands in spring, to consolidate ecological responses triggered by widespread floods in 2016–17. With continued dry conditions through the second half of summer and into autumn, the focus of deliveries of water for the environment shifted to protecting critical habitat. Top-up flows were delivered to Lake Hawthorn to provide habitat for waterbirds and to Brickworks Billabong to support the critically endangered Murray hardyhead.

The December flow pulse in the River Murray flooded the Nyah and Vinifera floodplains, Margooya Lagoon and Yungera Island, extending the period of inundation and providing connectivity between the floodplain and the River Murray. Rainfall, irrigation drainage and stormwater run-off were sufficient to meet ecological objectives at Koorlong Lake. Recent monitoring found over 700 Murray hardyhead in Koorlong Lake, proving that the population in the wetland is self-sustaining and robust.

Deliveries of water for the environment to Neds Corner in spring 2017 were halted on the advice of the Arthur Rylah Institute after monitoring through the Victorian Government's Wetland Monitoring and Assessment Program identified 15 rare, vulnerable or threatened plants in Neds Corner Central that had not been detected in the wetland before. Continuation of the watering may have displaced these plants. Management of the wetland has changed to reflect this finding: the approach is now to allow at least five years between inundation events where possible, to allow these threatened plants to establish. The wetland was last filled in 2016, so deliberate watering will not occur until at least 2021–22.

Scope of environmental watering

Table 5.2.13 shows potential environmental watering actions and their environmental objectives.

Environmental watering in 2018–19 will focus on maintaining and improving vegetation condition, habitat quality and availability throughout the wetlands, floodplains and waterways in the lower Murray area. Water for the environment may also be used to rehabilitate some salt-affected wetlands.

Table 5.2.13 Potential environmental watering actions and objectives for the lower Murray wetlands

Potential environmental watering	Environmental objectives
Wetland watering	
Bidgee Lagoons (fill in spring/summer)	• Maintain and promote the growth of vegetation that aligns with floodplain grassy wetland, pond herbland and shrubby riverine woodland ecological vegetation classes
Butlers Creek/Ducksfoot Lagoon (fill in spring/summer)	• Provide feeding habitat for waterbirds • Control noogoora burr
Brickworks Billabong (fill in spring or partial fill in autumn, as needed to maintain water-quality targets and minimum water level)	• Maintain and improve the condition of aquatic vegetation and water quality to increase the population of Murray hardyhead
Cardross Lakes Basin 1 East and West (partial fill in spring or as required to maintain water-quality targets and minimum water level)	
Koorlong Lake (partial fill as needed to maintain water-quality targets and minimum water level)	
Bullock Swamp (fill in winter/spring)	• Provide freshwater inflows and flushing flows to reduce salinity levels and improve the condition and diversity of wetland vegetation. • Improve ecological function
Burra Creek North (fill in winter/spring)	• Rehabilitate seasonal connectivity along Burra Creek • Improve the health and structure of the vegetation • Stimulate the growth of emergent and semiemergent aquatic vegetation
Burra Creek South (fill in winter/spring)	
Burra Creek South Proper (fill in winter/spring)	
Carina Bend wetlands (fill in winter/spring)	• Improve the condition of mature river red gum • Provide aquatic habitat to support fish and frogs • Provide habitat for waterfowl
Cowanna Billabong (fill in winter/spring)	• Increase wetland productivity • Provide feeding habitat for waterbirds

Table 5.2.13 Potential environmental watering actions and objectives for the lower Murray wetlands *continued*

Potential environmental watering	Environmental objectives
Inlet Creek Karadoc Swamp (fill in winter)	• Improve the condition of mature black box trees • Provide habitat to support frogs and fish • Provide habitat for waterbirds
Keera Wetland 1 (fill in spring) Keera Wetland 2 (fill in spring)	• Promote the growth of vegetation that aligns with the intermittent swampy woodland, lignum shrubland and lignum swampy woodland ecological vegetation classes
Lake Hawthorn (partial fill in spring or as required to maintain water at the minimum level)	• Support the growth of aquatic vegetation • Reintroduce saline marsh habitat • Provide habitat for waterbirds
Liparoo East (fill in winter) Liparoo West (fill in winter)	• Support seasonal habitat for small native fish • Provide feeding habitat for waterbirds • Maintain aquatic vegetation
Margooya Lagoon (fill in winter/spring/summer)	• Improve the condition of river red gums • Improve the native fish assemblage of the lagoon • Rehabilitate submerged aquatic vegetation in the open-water areas of the wetland
Nyah Floodplain (fill in spring/summer) Vinifera Floodplain (fill in spring/summer)	• Improve the condition and structure of wetland vegetation • Provide seasonal feeding and reproductive opportunities for native fish • Reestablish resident populations of frogs and small fish • Provide breeding habitat for waterbirds including colonial nesting species • Rehabilitate floodplain productivity to maintain the resident populations of terrestrial animals including carpet pythons, sugar gliders and grey-crowned babblers
Planigale Wetland (fill in winter/spring)	• Promote the growth of vegetation that aligns with the intermittent swampy woodland, lignum swampy woodland and riverine chenopod ecological vegetation classes • Improve habitat for mammals and reptiles • Support growling grass frogs
Tata North (fill in winter/spring)	• Maintain the health and structure of river red gum communities
Sandilong Creek (fill in spring/summer)	• Support catfish recruitment • Maintain fringing terrestrial vegetation
Woolshed Creek (fill in winter/spring)	• Improve the condition of woodland vegetation • Improve habitat for mammals and reptiles • Support growling grass frogs
Yungera Wetland (fill in winter/spring)	• Maintain and improve the health of river red gum and other floodplain trees
Wakool Creek (fill in spring/summer)	• Promote healthy and productive lignum shrubland • Provide habitat for waterbird nesting and roosting
Wetland drying	
Bridge Creek, Heywood Lake, J1 Creekline, Kings Billabong, Lake Carpul, Lake Powell, Little Heywood Lake, Neds Corner Central, Neds Corner East, Pound Bend Eastern wetlands, Robertson Wetland, Sandilong Billabong, Tata South	• These wetlands will not be actively watered in 2018–19 • Drying will promote the growth and establishment of vegetation in and surrounding the wetland, priming the system to support a wide range of wetland-dependent birds and animals

Scenario planning

Table 5.2.14 outlines the potential environmental watering and expected water use under a range of planning scenarios.

The highest-priority wetlands for environmental watering in 2018–19 under all climate scenarios and particularly in a drought scenario are Cardross Lakes, Lake Koorlong and Brickworks Billabong, as these sites support the critically endangered Murray hardyhead.

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 maximised as plants and animals respond to natural environmental cues.

Some wetlands will not be actively watered in 2018–19 and will be allowed to dry. This will allow some types of vegetation to germinate and establish, and it will increase the diversity of habitats available for aquatic plants and animals during the next wet phase. The dry phase will also provide opportunities for terrestrial animals to access temporary habitat and food.

Table 5.2.14 Potential environmental watering for 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)	• Brickworks Billabong • Cardross Lakes • Koorlong Lake	• Brickworks Billabong • Burra Creek North • Burra Creek South • Burra Creek South Proper • Butlers Creek • Cardross Lakes • Cowanna Billabong • Koorlong Lake • Lake Hawthorn • Margooya Lagoon • Nyah Floodplain • Sandilong Creek • Vinifera Floodplain • Yungera Wetland	• Brickworks Billabong • Bullock Swamp North • Burra Creek North • Burra Creek South • Burra Creek South Proper • Butlers Creek • Cardross Lakes Basin 1 East and West • Carina Bend wetlands • Cowanna Billabong • Koorlong Lake • Lake Hawthorn • Liparoo East • Liparoo West Billabong • Margooya Lagoon	• Brickworks Billabong • Bullock Swamp North • Burra Creek North • Burra Creek South • Burra Creek South Proper • Butlers Creek • Cardross Lakes Basin 1 East and West • Carina Bend wetlands • Cowanna Billabong • Koorlong Lake • Lake Hawthorn • Liparoo East • Liparoo West Billabong • Margooya Lagoon

Table 5.2.14 Potential environmental watering for lower Murray wetlands under a range of planning scenarios *continued*

Planning scenario	Drought	Dry	Average	Wet
Potential environmental watering – tier 1 (high priorities)			• Nyah Floodplain • Planigale Wetland • Sandilong Creek • Vinifera Floodplain • Woolshed Wetland • Yungera Wetland	• Nyah Floodplain • Planigale Wetland • Sandilong Creek • Vinifera Floodplain • Woolshed Wetland • Yungera Wetland
Potential environmental watering – tier 2 (additional priorities)		• Bidgee Lagoons • Tata Creek North • Wakool Creek	• Bidgee Lagoons • Tata Creek North • Wakool Creek	• Inlet Creek (Karadoc) • Keera Wetland 1 • Keera Wetland 2
Possible volume of water for the environment required to meet objectives[1]	• 1,400 ML (tier 1) • 0 ML (tier 2)	• 5,950 ML (tier 1) • 2,700 ML (tier 2)	• 10,300 ML (tier 1) • 2,700 ML (tier 2)	• 2,950 ML (tier 1) • 1,450 ML (tier 2)

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

Risk management

Environmental watering program partners have considered and assessed risks and identified mitigating strategies relating to environmental flows in 2018–19. Risks and mitigating actions are continually reassessed by program partners throughout the water year (see section 1.3.6).

Engagement

Table 5.2.15 shows the partners and stakeholder organisations with which Mallee CMA engaged when preparing the lower Murray wetlands seasonal watering proposal.

Seasonal watering proposals are informed by longer-term regional catchment strategies, regional waterway strategies, environmental flow studies, water management plans and other studies. These incorporate a range of environmental, cultural, social and economic perspectives and longer-term integrated catchment and waterway management objectives. For further details, refer to the *Mallee Regional Catchment Strategy* and the *Mallee Waterway Strategy*.

Table 5.2.15 Partners and stakeholders engaged in developing the lower Murray wetlands seasonal watering proposal

Partner and stakeholder engagement
• Commonwealth Environmental Water Office
• Department of Environment, Land, Water and Planning
• Environmental groups (Trust for Nature, Nyah and Districts Action Group, Nyah and Districts Weed Warriors, Sustainable Living in the Mallee, Mallee Fowl Recovery Group, Mid-Murray Field Naturalists)
• Four friends groups
• Goulburn-Murray Water
• Lake Lascelles Committee
• Lake Tchum Committee
• 25 Landcare groups
• Lower Murray Water
• Mallee Aboriginal Reference Group
• Mallee CMA Water Technical Advisory Committee (an advisory group to Mallee CMA comprising community members)
• Mallee District Aboriginal Services
• Meringur Historical Society
• Mildura Birdlife, Wildside outdoors – canoeing, Mildura 4WD Inc.
• Mildura Rural City and Swan Hill Rural City councils
• Murray–Darling Basin Authority
• Parks Victoria
• Recreational groups (Sunraysia Apiarists Association, Riverside Golf Course, Sunraysia Bushwalkers
• Victorian Environmental Water Holder

5.2.6 Lindsay, Mulcra and Wallpolla islands

The Lindsay, Mulcra and Wallpolla islands cover over 26,100 ha of Victorian floodplain in the Murray-Sunset National Park (Figure 5.2.6). They form part of the Chowilla Floodplains–Lindsay–Wallpolla Islands Living Murray icon site that straddles the Victoria and South Australia border. Lindsay Island, Wallpolla Island and Lake Wallawalla are recognised as nationally-important wetlands.

The wetlands and waterways in the Lindsay, Mulcra and Wallpolla islands system hold significance for Traditional Owners and their Nations. Currently there is no Registered Aboriginal Party for the region and the Mallee Catchment Management Authority involves the region's Traditional Owners in in the management of Lindsay, Mulcra and Wallpolla islands through its Aboriginal Reference Group, which includes First Peoples of the Millewa-Mallee and the Wadi Wadi and Tati Tati Traditional Owners.

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 the improved productivity and food resources when the system floods. During dry periods, large floodplain wetlands (such as Lake Wallawalla) can retain water and provide important refuge areas for wetland-dependent species and support terrestrial animals (such as small mammals and reptiles).

Mullaroo Creek and the Lindsay River are renowned for supporting 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 they contrast with the slow-flowing and still habitats in the nearby River Murray. Mature breeding fish in these waterways are an important source of juveniles for the overall Murray system. Waterways and wetlands throughout the icon site also support several other threatened fish species (such as the 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, which has in turn caused declines in the diversity and abundance of animals that rely on healthy vegetation for habitat.

Environmental watering objectives in Lindsay, Wallpolla and Mulcra islands

	Increase the diversity, extent and abundance of wetland plants
	Increase the diversity, abundance and distribution of native fish Provide flows for large-bodied fish (including Murray cod and golden perch) to feed and breed
	Provide feeding and breeding habitat for a range of waterbird species including threatened, migratory and colonial nesting species (such as egrets)

Social and economic values

Lindsay, Mulcra and Wallpolla islands offer recreation opportunities in a remote location with camping, boating, fishing popular with residents of nearby communities and long-distance travellers. The area provides many birdwatching opportunities: over 200 aquatic and arid species are known to use the site.

System overview

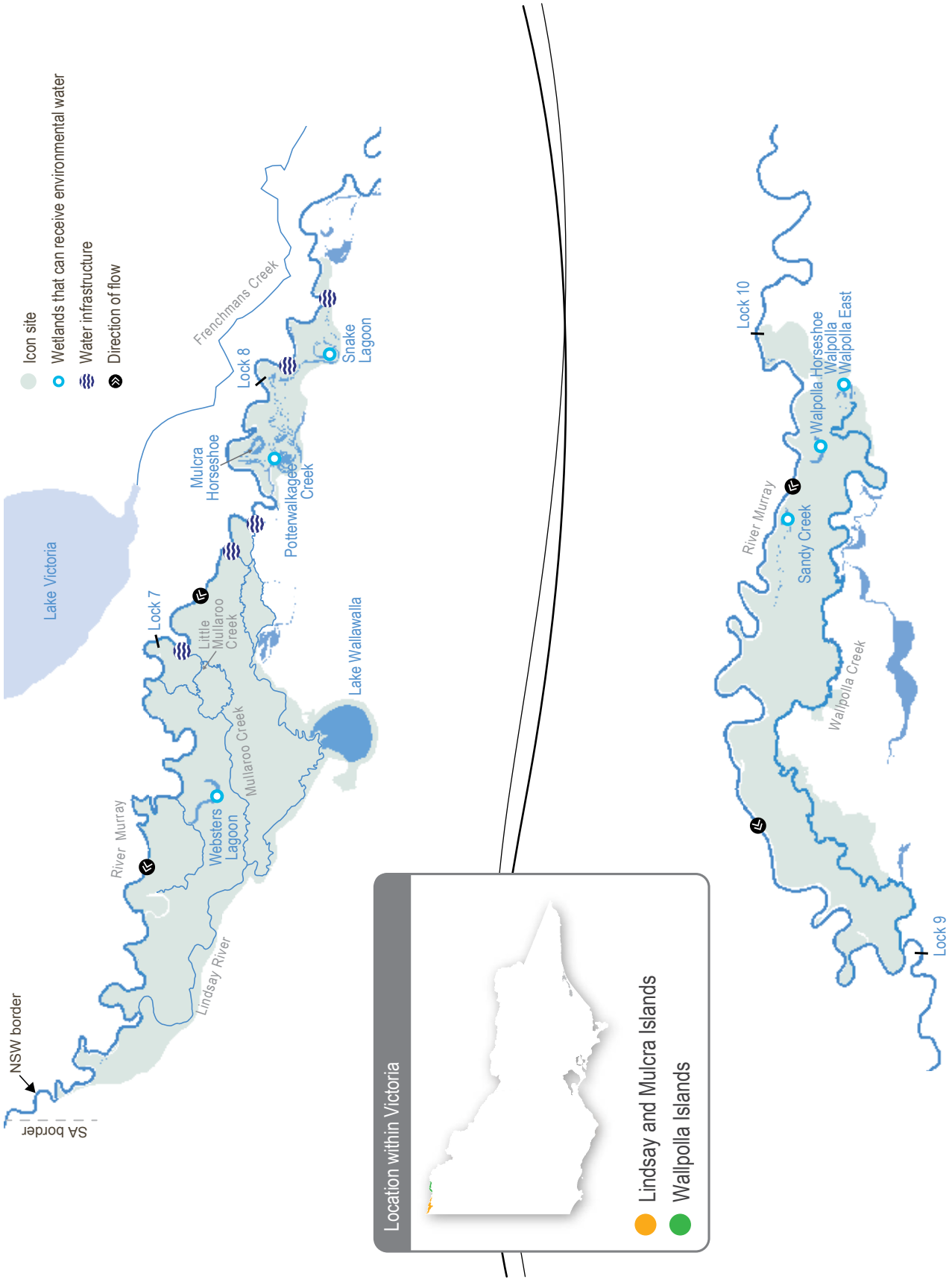
The Lindsay, Mulcra and Wallpolla islands floodplain is characterised by a network of permanent waterways, small creeks and wetlands. The Lindsay River, Potterwalkagee Creek and Wallpolla Creek form the southern boundaries of the site and create large floodplain islands with the River Murray to the north.

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 regulation of the River Murray has significantly reduced the frequency of small- to moderate-sized floods.

Under current system operations, most flows through Lindsay, Mulcra and Wallpolla islands are regulated by the River Murray locks 6 to 9. Depending on weir pool height, water can be diverted from the River Murray to the Lindsay River and to Mullaroo and Potterwalkagee creeks through several regulators and at varying flow rates. Levees and regulators have also been built throughout the Lindsay, Mulcra and Wallpolla floodplain to direct, retain and release water as needed to improve the environmental values at the site.

The Murray–Darling Basin Authority is responsible for managing weir pool levels in the River Murray. Multiple agencies work together to coordinate flows and weir pool levels to achieve environmental outcomes in the River Murray and within the Lindsay, Mulcra and Wallpolla islands icon site.

Figure 5.2.6 Lindsay, Mulcra and Wallpolla islands



Recent conditions

Much of the Lindsay, Mulcra and Wallpolla islands floodplain remained dry during the Millennium Drought. Floods in 2010–11 filled the wetlands and inundated black box woodland and lignum shrubland for the first time in more than 15 years. The floods in 2016 were larger, with peak flows in the River Murray ranging from about 105,000 ML per day at Wentworth and 95,000 ML per day at the South Australian border.

Water for the environment is delivered through anabranch waterways and to individual wetlands to supplement natural floods and support ecological values and processes that rely on more-frequent inundation. The focus of deliveries of water for the environment in 2017–18 was to maintain flowing habitat for fish recruitment and survival by providing flow through Mullaroo Creek, Lindsay River and Potterwalkagee Creek. Water for the environment was also pumped to Lake Wallawalla to maintain waterbird habitat and increase wetland plant growth and productivity.

Scope of environmental watering

Table 5.2.16 shows potential environmental watering actions and their environmental objectives.

Table 5.2.16 Potential environmental watering actions and objectives for the Lindsay, Mulcra and Wallpolla islands

Potential environmental watering	Environmental objectives
Lindsay Island – Mullaroo Creek	
Year-round low flows (600–800 ML/day)	• Maintain flowing water habitat for native fish species (such as Murray cod, silver perch and golden perch)
Spring high flow (up to 1,200 ML/day for up to 3 months between September–November)	• Initiate fish movement and improve spawning and recruitment opportunities for native fish
Autumn high flow (up to 1,000 ML/day for 1 month between April–May)	• Provide an early-season flow to stimulate return of large-bodied fish
Lindsay Island – Lindsay River	
Year-round low flows (40 ML/day via the northern regulator)	• Maintain flowing water habitat for native fish species such as Murray cod, silver perch and golden perch
Spring high flow (up to 450 ML/day for up to 3 months between September–November via the northern regulator)	• Initiate fish migration and improve spawning and recruitment opportunities for native fish
Spring high flow (up to 200 ML/day for up to 3 months between September–November via the southern regulator)	• Extend flowing water habitat for native fish species, providing spawning and recruitment opportunities
Autumn high flow (up to 200 ML/day for 1 month between April–May via the northern regulator)	• Provide an early-season flow to stimulate return of large-bodied fish
Lindsay Island wetlands	
Lake Wallawalla (partial fill in autumn)	• Stimulate an increase in available food sources and productivity levels for aquatic and wetland plant species • Maintain habitat for waterbirds
Websters Lagoon (partial or complete fill at any time)	• Maintain wetland habitat for fish and waterbirds
Mulcra Island – Potterwalkagee Creek	
Year-round low flows in lower Potterwalkagee Creek (100–400 ML/day via the Stony Crossing regulator)	• Maintain flowing water habitat for native fish species (such as Murray cod, silver perch and golden perch)
Winter/spring/summer low flows in upper Potterwalkagee Creek (up to 100 ML/day between June–February via the upper Potterwalkagee Creek regulator)	• Maintain seasonal flowing water habitat for native fish species (such as Murray cod, silver perch and golden perch)

Table 5.2.16 Potential environmental watering actions and objectives for the Lindsay, Mulcra and Wallpolla islands *continued*

Potential environmental watering	Environmental objectives
Spring/summer high flows in lower Potterwalkagee Creek (up to 400 ML/day for 3 months between September–January via the Stony Crossing regulator and upper Potterwalkagee Creek Regulator)	• Initiate fish movement and improve spawning and recruitment opportunities for native fish
Spring/summer high flows in upper Potterwalkagee Creek (up to 150 ML/day for 3 months between September–January via the upper Potterwalkagee Creek regulator)	
Mulcra Island wetlands	
Snake Lagoon (partial or complete fill in winter/spring)	• Improve wetland productivity and provide habitat for wetland birds and fish
Mulcra Horseshoe (partial or complete fill in winter/spring)	
Wallpolla Island	
Wallpolla Horseshoe (partial or complete fill any time)	• Maintain variable water levels in the littoral zone to improve wetland productivity • Control river red gum saplings
Wallpolla East (partial or complete fill in spring or autumn)	• Improve condition of the riverine grassy woodland and floodway pond herbland ecological vegetation classes • Provide temporary habitat for aquatic species with productivity transferred to creek lines
Sandy Creek (partial or complete fill in spring or autumn)	• Improve the condition of the grassy riverine forest and floodway pond herbland ecological vegetation classes

Scenario planning

Table 5.2.17 outlines the potential environmental watering and expected water use under a range of planning scenarios.

The main focus of environmental watering in 2018–19 is to provide variable, flowing water habitat through Lindsay River, Mullaroo Creek and Potterwalkagee Creek. Low flows must be provided all year round in Lindsay River (via the northern regulator), Potterwalkagee Creek (via the Stony Crossing regulator) and Mullaroo Creek, to protect resident fish populations. While low flows are required under all climate scenarios, their magnitude may vary depending on seasonal conditions and weir pool operations.

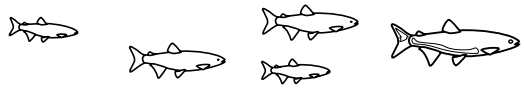
Apart from dry or drought scenarios, a long-duration high flow in spring is a high priority for all waterways, to stimulate fish movement and breeding. Under very wet conditions, an autumn fresh may be needed to stimulate the return of fish from the River Murray to the anabranches. Any managed high flows will be provided through all regulators that connect with the River Murray and will be coordinated with weir pool operations.

A high priority under wetter conditions is delivery of up to 8,000 ML of water for the environment to Lake Wallawalla in autumn. Water levels in Lake Wallwalla are receding after water for the environment was delivered in spring 2017, and a partial fill in autumn 2019 will prime the wetland for a complete fill in spring 2019. On Wallpolla Island, small-scale deliveries of water for the environment to Sandy Creek, Wallpolla East and Wallpolla Horseshoe are planned under all scenarios.

Table 5.2.17 Potential environmental watering for Lindsay, Mulcra and Wallpolla islands under a range of planning scenarios

Planning scenario	Very dry	Dry	Average	Very 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	• Year-round low flow	• Year-round low flow	• Year-round low flow • 1 spring high flow	• Year-round low flow • 1 spring high flow • 1 autumn high flow
Wetlands			• Lake Wallawalla (partial fill) • Websters Lagoon (partial to complete fill)	• Lake Wallawalla (partial fill) • Websters Lagoon (complete fill)
Water demand[1]	• <2,000 ML	• <2,000 ML	• < 2,000–10,000 ML	• < 2,000–10,000 ML
Mulcra Island				
Lower Potterwalkagee Creek via regulators	• Year-round low flow	• Year-round low flow	• Year-round low flow • 1 spring high flow	• Year-round low flow • 1 spring high flow
Upper Potterwalkagee Creek via regulator	• Year-round low flow	• Year-round low flow	• Year-round low flow • 1 spring high flow	• Year-round low flow • 1 spring high flow
Wetlands and floodplain				• Snake Lagoon (complete fill) • Mulcra Horseshoe (complete fill)
Water demand[1]	• <2,000 ML	• <2,000 ML	• <2,000 ML	• <2,000 ML
Wallpolla island				
Wetlands	• Wallpolla Horseshoe (partial fill)	• Wallpolla Horseshoe (partial fill)	• Wallpolla Horseshoe (complete fill) • Sandy Creek (partial or complete fill)	• Wallpolla Horseshoe (complete fill) • Sandy Creek (partial or complete fill) • Wallpolla East (partial or complete fill)
Water demand	• 1,000 ML	• 1,000 ML	• 1,600 ML	• 2,300 ML–2,600 ML

[1] *Volume includes the estimated volume of water for the environment required to underwrite the losses associated with the delivery of consumptive water en route (for flows in Mullaroo Creek, Lindsay River, Potterwalkagee Creek and Mulcra Island).*



Risk management

Environmental watering program partners have considered and assessed risks and identified mitigating strategies relating to environmental flows in 2018–19. Risks and mitigating actions are continually reassessed by program partners throughout the water year (see section 1.3.6).

Engagement

Table 5.2.18 shows the partners and stakeholder organisation with which Mallee CMA engaged when preparing the Lindsay, Mulcra and Wallpolla islands seasonal watering proposal.

Seasonal watering proposals are informed by longer-term regional catchment strategies, regional waterway strategies, environmental flow studies, water management plans and other studies. These incorporate a range of environmental, cultural, social and economic perspectives and longer-term integrated catchment and waterway management objectives. For further details, refer to the *Mallee Regional Catchment Strategy* and *Mallee Waterway Strategy*.

Table 5.2.18 Partners and stakeholders engaged in developing the Lindsay, Mulcra and Wallpolla islands seasonal watering proposal

Partner and stakeholder engagement
• Commonwealth Environmental Water Office • Department of Environment, Land, Water and Planning • Four friends groups • Goulburn-Murray Water • Lake Lascelles Committee • 24 Landcare groups (24) • Mallee CMA Aboriginal Reference Group, including First Peoples of the Millewa-Mallee and members of the Wadi Wadi and Tati Tati Traditional Owners groups • Mallee CMA Water Technical Advisory Committee (an advisory group to Mallee CMA comprising community members) • Mallee Fowl Recovery Group • Meringur Historical Society • Mid-Murray Field Naturalists • Mildura Rural City Council • Murray–Darling Basin Authority • Parks Victoria Recreational users (Sunraysia bushwalkers, Birdlife Australia (Mildura), Mildura 4WD Inc.) • Sustainable Living in the Mallee • Victorian Environmental Water Holder

5.3 Ovens system

Waterway manager – North East Catchment Management Authority

Storage manager – Goulburn-Murray Water

Environmental water holder – Commonwealth Environmental Water Holder

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.

The Ovens River and its floodplain continue to be places of significance for Traditional Owners and their Nations including the Yorta Yorta, Bangarang, Taungurung and Dhudhuroa peoples. The Registered Aboriginal Parties in the Ovens system are the Yorta Yorta Nation Aboriginal Corporation in the Lower Ovens and the Taungurung Clans Aboriginal Corporation in the upper King area.

Environmental values

The diverse aquatic habitat and abundant food resources associated with the Ovens system support a wide range of native fish species including the Murray cod, trout cod, golden perch and fly-specked hardyhead. The Buffalo River provides valuable habitat for large 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. The Ovens system has seen a successful recovery project for trout cod, and efforts to reintroduce Macquarie perch are continuing.

Frogs (such as the giant bullfrog and growling grass frog) are abundant in the lower reaches of the Ovens River and associated wetlands and in the King River upstream of Cheshunt. The lower Ovens wetland complex containing 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 vegetation along the rivers consist mainly of river red gum forest and woodland, which are among the healthiest in Victoria.

Environmental watering objectives in the Ovens system

	Provide flows for native fish to move between pools and over rocky or shallow parts of the river
	Maintain the form of the riverbank and channel plus a range of different river bed surfaces to support all stream life
	Maintain water quality for all river life
	Provide habitat for a wide range of waterbugs which break down organic matter and support the river's food chain

Social and economic values

The Ovens River supports various recreational activities including fishing, boating, kayaking, swimming and bushwalking. Irrigation supports the food and wine industries that attract tourists to the region. The lower Ovens–River Murray weir pool associated with Lake Mulwala is another tourist drawcard.

System overview

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) and has a relatively small need for water for the environment compared with other large, more highly regulated rivers in Victoria.

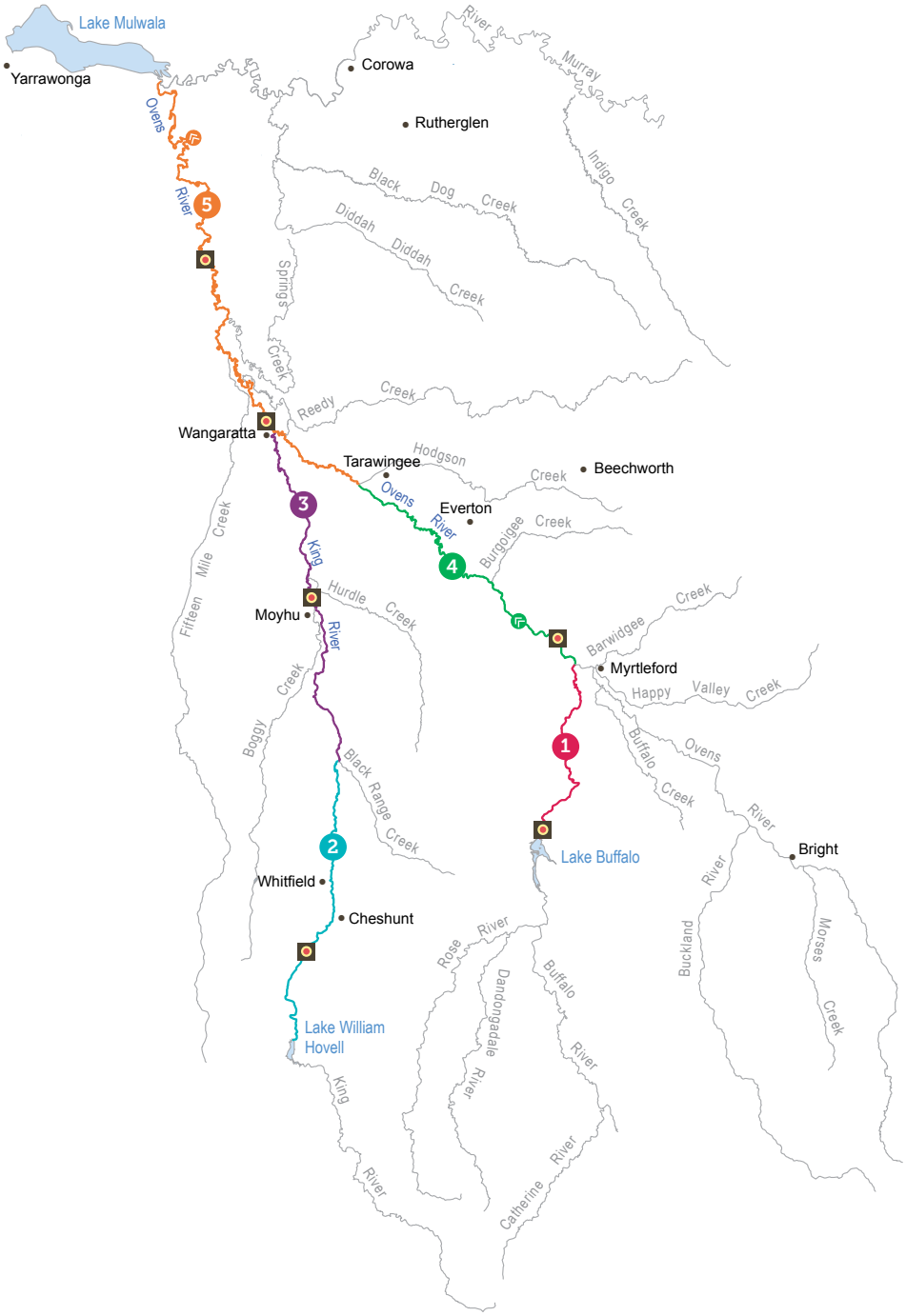
The Ovens River flows into Lake Mulwala on the River Murray, the largest weir pool on the Murray regulated system. Ovens River flows contribute to the reliability and variability of the flow regime for the River Murray and support many downstream uses including irrigation, urban supply and watering of 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 for the environment available and it is well short of the volume required to meet all flow objectives. Despite the small volume, the use of water for the environment is carefully planned to deliver the greatest possible benefit. Water for the environment can be used to directly manage parts of the flow regime in reaches immediately downstream of the two main storages, or it can be paired with consumptive water releases to influence flow further downstream in the lower Ovens River.

Figure 5.3.1 The Ovens system

Reach 1 Buffalo River: Lake Buffalo to the Ovens River
Reach 2 King River: Lake William Hovell to Moyhu
Reach 3 King River: Moyhu to the Ovens River
Reach 4 Ovens River: Buffalo River to Everton/Tarrawingee
Reach 5 Ovens River: Everton/Tarrawingee to the Murray River at Lake Mulwala
Measurement point
Town
Indicates direction of flow

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

High rainfall and large-scale flooding in the Ovens River catchment in winter/spring 2016 filled Lake Buffalo and Lake Hume Hovell. Since then, the winter/spring and summer of 2017–18 was warmer than average, with below-average rainfall resulting in lower-than-average inflows to Lake Buffalo and Lake William Hovell in most months. Despite the drier conditions, the storages filled and spilled, resulting in natural flow patterns downstream and in the lower Ovens River. Lake William Hovell was full for most of winter/spring, while Lake Buffalo filled and spilled following a large rainfall event in December 2017. In autumn 2018, 73 ML of water for the environment was released from Lake Buffalo to maintain flow variability and water quality in the Buffalo River, and 50 ML was released from Lake William Hovell to meet similar objectives in the King River.

Scope of environmental watering

Table 5.3.1 shows potential environmental watering actions and their environmental objectives.

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

Potential environmental watering	Environmental objectives
Summer/autumn low-flow fresh in reaches 1, 4 and 5 (1 fresh of 430 ML/day for 3 days in reaches 1 and 4, 130–260 ML/day in reach 5 in December–May)	Provide flow cues to stimulate movement of native fish Maintain connectivity between pools for fish movement and water quality Provide small variations in river levels to move sediment and maintain waterbug habitat Scour biofilm from the river bed
Provide 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

[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.

The 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 flows ceasing in the reaches immediately below the storages. As conditions become wetter, there are more opportunities to piggyback environmental releases on consumptive water releases from Lake Buffalo 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 because of releases. Under wet conditions, the storages are very likely to spill due to their small capacity. 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[1]
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	• Summer/autumn low flows	• Summer/autumn fresh • Summer/autumn low flows	• None required
Possible volume of water for the environment required to meet objectives	• 123 ML	• 123 ML	• 0 ML

[1] *Spill conditions likely to mean water for the environment cannot be released under wet conditions.*

Risk management

Environmental watering program partners have considered and assessed risks and identified mitigating strategies relating to environmental flows in 2018–19. Risks and mitigating actions are continually reassessed by program partners throughout the water year (see section 1.3.6).

Engagement

Table 5.3.3 shows the partners with which North East CMA engaged when preparing the Ovens system seasonal watering proposal.

Seasonal watering proposals are informed by longer-term regional catchment strategies, regional waterway strategies, environmental flow studies, water management plans and other studies. These incorporate a range of environmental, cultural, social and economic perspectives and longer-term integrated catchment and waterway management objectives. For further details, refer to the *North East Regional Catchment Strategy* and *North East Waterway Strategy*.

Table 5.3.3 Partners engaged in developing the Ovens system seasonal watering proposal

Partner engagement
• Commonwealth Environmental Water Office • Goulburn-Murray Water • Victorian Environmental Water Holder

5.4 Goulburn system

Waterway manager – Goulburn Broken Catchment Management Authority

Storage manager – Goulburn-Murray Water

Environmental water holders – Commonwealth Environmental Water Holder, Victorian Environmental Water Holder, Murray–Darling Basin Authority (the Living Murray program)

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. It supports large areas of intact river red gum forest and floodplain wetlands, and it provides habitat for threatened and endangered bird and fish species. Several wetlands in the Goulburn Broken catchment are formally recognised for their conservation significance.

There are several environmental water holders in the Goulburn system. The Commonwealth Environmental Water Holder (CEWH) is the largest holder of water for the environment and use of Commonwealth water for the environment is critical to achieving outcomes in the Goulburn River. Water for the environment held on behalf of the Living Murray program may also assist in meeting objectives in the Goulburn system en route to icon sites in the Murray system (see section 1.4.2). Water held by the VEWH in the Goulburn system is used to meet environmental objectives in the river and the Goulburn wetlands.

Engagement

Table 5.4.1 shows the partners and stakeholder organisations that Goulburn Broken CMA engaged when preparing the Goulburn River and Goulburn wetlands seasonal watering proposal.

Seasonal watering proposals are informed by longer-term regional catchment strategies, regional waterway strategies, environmental flow studies, water management plans and other studies. These incorporate a range of environmental, cultural, social and economic perspectives and longer-term integrated catchment and waterway management objectives. For further details, refer to the *Goulburn Broken Regional Catchment Strategy* and *Goulburn Broken Waterway Strategy*.

Table 5.4.1 Partners and stakeholders engaged in developing the Goulburn system seasonal watering proposal

Partner and stakeholder engagement
• Commonwealth Environmental Water Office
• Goulburn Environmental Water Advisory Group (includes recreational users, local environment groups and landholders)
• Goulburn-Murray Water
• Parks Victoria
• Taungurung Clans Aboriginal Corporation
• Victorian Environmental Water Holder
• Yorta Yorta Nation Aboriginal Corporation

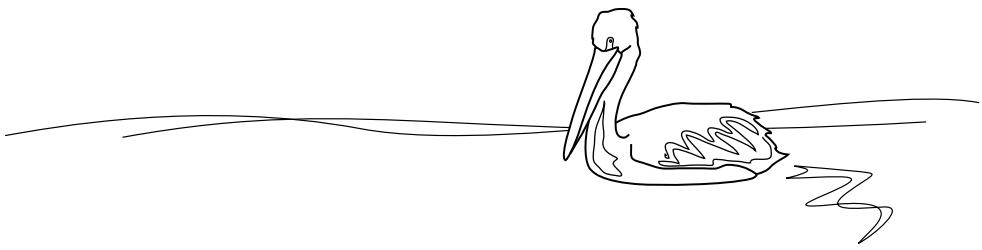
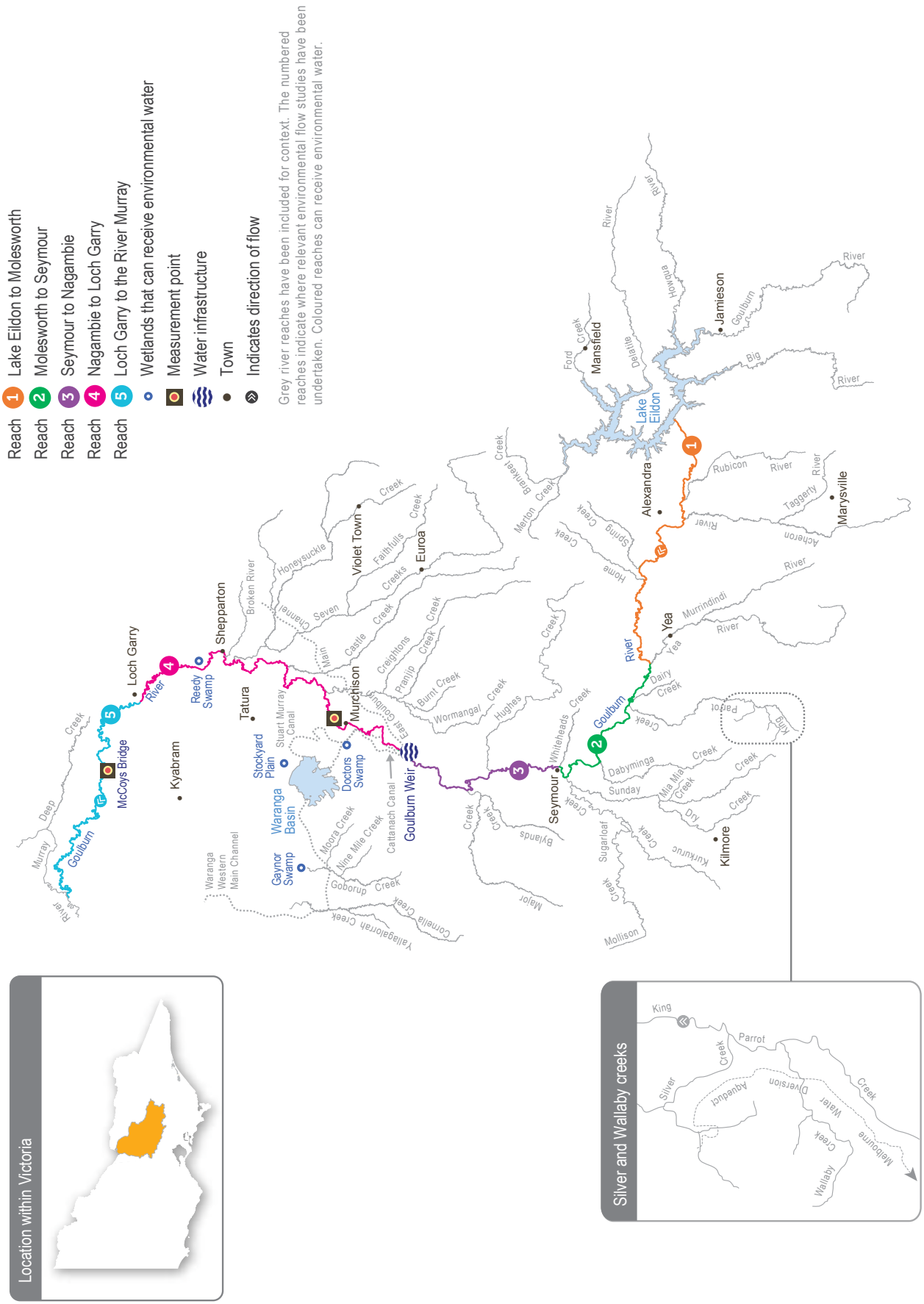


Figure 5.4.1 The Goulburn system



5.4.1 Goulburn River

The Goulburn River flows for 570 km from the Great Dividing Range upstream of Woods Point to the River Murray east of Echuca.

The Goulburn River and its floodplain continue to be places of importance for Traditional Owners and their Nations including the Yorta Yorta and Taungurung Peoples. The Registered Aboriginal Parties (RAPs) in the Goulburn River catchment are the Yorta Yorta Nation Aboriginal Corporation and the Taungurung Clans Aboriginal Corporation. Both the Yorta Yorta Nation and Taungurung Clans Aboriginal Corporations were engaged during development of the Goulburn River seasonal watering proposal.

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. Its aquatic vegetation, scour holes and structural, woody debris provide high-quality habitat for adult and juvenile fish. The bank vegetation is dominated by river red gums, which provide stream shading and habitat for many species including the squirrel glider. Birds (such as egrets, herons and cormorants) use trees along the river to roost and feed, while frogs benefit from shallowly inundated vegetation along the river fringes and in adjacent wetlands.

The Goulburn River system is an important conservation area for threatened species. Mid-Goulburn River tributaries 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 the Goulburn River in reach 3. Monitoring in the lower Goulburn River below the Goulburn Weir shows successful spawning in response to environmental flows of golden and silver perch and trout cod.

Social and economic values

The Goulburn Broken catchment covers two percent of the area of the Murray–Darling Basin and contributes 11 percent of the total water for use in the basin, with the majority contributed from the Goulburn River. Most of the water taken from the Goulburn system is used to irrigate crops and pasture, with the rest providing water for towns and stock and domestic users. The Goulburn River is popular for recreation, fishing and boating. Fishing in particular provides substantial economic and social benefits to the region.

Environmental watering objectives in the Goulburn River

	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
	Protect and boost populations of native fish (including golden perch) by increasing the availability of habitat and by encouraging fish to migrate and spawn
	Maintain the form of the riverbank and channel, including a high diversity of river bed surfaces to support all stream life
	Provide habitat and food for waterbugs, which break down organic matter and support the river's food chain

System overview

The construction and operation of Lake Eildon and Goulburn Weir have significantly altered the natural flow regime of the Goulburn River. Water harvesting during naturally 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. Several tributaries including the Yea River and the Broken River outfall downstream of Lake Eildon and 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 associated environmental values.

Water for the environment may need to be delivered through the Goulburn system to meet environmental objectives at downstream sites. These releases generally target Living Murray icon sites and where possible are delivered in a way that provides environmental benefits to the Goulburn River en route.

Environmental targets can also be met by the coordinated delivery of consumptive water being transferred from Lake Eildon to the River Murray (known as inter-valley transfers). These transfers occur during the irrigation season between spring and autumn and may meet environmental flow objectives without the need to release environmental water.

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. They are the most-flow-stressed sections of the river and support abundant and diverse native fish communities. 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 targets, so it has little need for environmental water. 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.

Recent conditions

The Goulburn catchment has experienced mainly dry conditions over the last five years, except in 2016–17 when unregulated flows caused overbank flooding. Most of the flow variation in the lower Goulburn River in 2017–18 was due to releases of water for the environment rather than natural (unregulated) flows. The exceptions were two unregulated flow events in August (peaking at 6,400 ML per day at Shepparton) and December 2017 (peaking at 23,000 ML per day at Shepparton). The high flows in December caused an influx of organic matter that, coupled with warmer weather, lowered the dissolved oxygen concentration in the river. A similar, unregulated event in 2016–17 caused a hypoxic blackwater event, but water for the environment was successfully used during the December 2017 event to prevent the further decline of oxygen levels and avoid stress to aquatic animals.

Water for the environment was used to deliver a winter fresh in late-June to early-July 2017 to improve bank vegetation, water quality and waterbug and fish habitat. Improving the condition of bank vegetation early in the year increases the resilience of plant communities and enables them to better withstand the effects of high river flows due to irrigation deliveries in the following summer and autumn.

Water for the environment was used when necessary throughout the year to meet minimum low flow requirements in the lower Goulburn River, to maintain habitat for in-stream animals and to support bank vegetation. Low flows of 400 ML per day were also delivered for the first time in reach 1 of the Goulburn River between July and September 2017 to maintain riffle habitats that are often exposed at that time.

Managers of water for the environment provided advice to river operators about how to shape a summer inter-valley transfer in a way that provided some environmental benefits. Inter-valley transfers can significantly exceed the recommended summer flows and compromise environmental outcomes. In this case, the transfers were shaped to produce two peak flows of 2,900 ML per day over 20 days in summer, to encourage juvenile golden perch and silver perch to move from the River Murray into the lower Goulburn River. Water for the environment is planned to be used to deliver a winter fresh event in June and July 2018 to maintain bank vegetation as well as waterbug and fish habitat in the lower Goulburn.

The vast majority of water for the environment delivered in the Goulburn River is reused at downstream sites along the River Murray. In 2017–18, Goulburn water was reused to meet native fish objectives in Gunbower Creek, to achieve large-scale floodplain inundation in Hattah Lakes, to fill Lake Wallawalla at Lindsay Island and to benefit native fish in the Lower Lakes, Coorong and Murray Mouth in South Australia.

Goulburn River near Swing Bridge, Shepparton, by Goulburn Broken CMA

Scope of environmental watering

Table 5.4.2 shows potential environmental watering actions and their environmental objectives.

Table 5.4.2 Potential environmental watering actions and objectives for the Goulburn River

	Potential environmental watering[1]	Environmental objectives
1	Year-round low flows (500 ML/day in reach 4 and 540 ML/day in reach 5)	• Maximise habitat and movement opportunities for large and small-bodied native fish • Provide conditions that support habitat and food for waterbugs; these include maintaining suitable water quality, submerging snags and encouraging plankton production • Maintain lower bank and emergent vegetation
2	Spring fresh (1 fresh of up to 10,000 ML/day with flows above 6,000 ML/day for 14 days in reach 4 and 5 in September–November)	• Maintain the bank vegetation by watering banks and benches to provide soil moisture to sustain growth and stimulate flowering and seed development • Increase the vegetation extent by distributing seed to river banks and stimulating germination • Maintain macrophyte, waterbug and fish habitat by mobilising fine sediments, submerging snags and replenishing slackwater habitat
3a	Increased year-round low flows (830 ML/day in reach 4 and/or 940 ML/day in reach 5)	• Maintain lower bank and emergent vegetation • Provide conditions that support habitat and food for waterbugs including by maintaining suitable water quality, submerging additional snags, entraining leaf litter and disrupting biofilms
3b	Winter/spring variable low flows (up to 1,500 ML/day in reach 4 in June–November)	• Increase sediment and seed deposition on banks and benches • Increase and improve habitat for waterbugs
4	Autumn fresh (1 fresh of up to 6,000 ML/day for two days in March–May)	• Maintain vegetation established during the spring fresh and encourage new seed germination • Provide conditions that support waterbugs including improved water quality and increased biofilm availability by mobilising fine sediment
5	Winter fresh (1 fresh of up to 15,000 ML/day with flows above 6,600 ML/day for 14 days in June–July 2019)	• Maintain macrophyte, waterbug and fish habitat by mobilising fine sediments, submerging snags and replenishing slackwater habitat
6	Autumn/winter/spring low flows (400 ML/day in reach 1 in April–September)	• Maintain and improve habitat for small-bodied native fish, waterbugs and aquatic vegetation
7[2]	Spring/summer fresh (1 fresh of up to 10,000 ML/day for 2 days in reach 4 and reach 5 in November–December)	• Initiate spawning and pre-spawning migrations and recruitment of golden perch • Maintain macrophyte, waterbug and fish habitat by mobilising fine sediments, submerging snags and replenishing slackwater habitat
8[2]	Summer fresh (1 fresh of up to 4,600 ML/day for 10 days in reach 4 and reach 5 in January–November)	• Stimulate the migration of juvenile native fish into the Goulburn River from the River Murray

[1] *Water for the environment may be used to slow the recession of unregulated flows or operational releases to reduce damage to banks and vegetation from rapid drops in water levels, or to add pulses following unregulated flows to maximise the ecological benefits of these events. This also helps prevent waterbugs and fish from being stranded in small pools on riverbanks or benches following higher flows.*

[2] *These watering actions are included as contingency actions only and are not planned to be delivered under the expected scenarios in 2018–19.*

Scenario planning

Table 5.4.3 outlines the potential environmental watering actions 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 for the environment to provide low flows in winter and spring 2019 is only required in dry or very dry conditions. 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 2019–20. This means that instead of carrying over water into the next season, it can be used to contribute to environmental watering events planned for 2018–19.

The highest-priority watering actions in 2018–19 aim to sustain the growth, flowering and seed development of emergent and bank vegetation. The long duration of high flows in summer 2017–18 mean that lower, bank-fringing vegetation has been under water for much of the past 18 months. Maintaining and encouraging germination of fringing vegetation is the primary focus of environmental watering in the Goulburn River for 2018–19.

In the last few years, deliveries of water for the environment supported native fish spawning and migration. Although water has not been specifically set aside to provide specific fish spawning or migration flows in 2018–19, fish passage and habitat will be provided through year-round low flows below Goulburn Weir (reaches 4 and 5). As well, these low flows encourage the establishment of aquatic and amphibious vegetation and provide habitat and food for waterbugs and small-bodied fish by submerging snags and encouraging plankton production.

Under extreme dry conditions, there is less water for the environment available and some actions may only be partially delivered or not delivered at all. Under dry conditions, almost all actions can be delivered although the magnitude and duration of the autumn fresh may need to be reduced, and there may be less opportunity to build on naturally occurring events. Under average conditions, it is expected that all actions will be delivered except a winter fresh, and under wet conditions all actions can be delivered in full. Delivering more watering actions will have the biggest benefit to the health of the river. Tier 2 actions may be implemented if more water becomes available.

Goulburn Weir, by Courtney Johnson

Table 5.4.3 Potential environmental watering for the Goulburn River under a range of planning scenarios

Planning scenario	Extremely dry	Dry	Average	Wet
Expected river conditions	• No unregulated flows	• Unregulated flows expected to provide some low flows between winter to mid-spring and likely small winter/spring freshes	• Unregulated flows expected to provide low flows for most of the year and likely medium winter/spring freshes	• Unregulated flows expected to provide low flows and multiple overbank flows events in winter/spring
	• Normal minimum passing flows at reach 5 of 400 ML/day from July–October and 350 ML/day from November–June			
Expected availability of water for the environment	• 25,000 ML carryover • 6,000 ML VEWH • 106,000 ML CEWH • 15,000 ML Living Murray • 152,000 ML total	• 25,000 ML carryover • 13,000 ML VEWH • 234,000 ML CEWH • 33,000 ML Living Murray • 305,000 ML total	• 25,000 ML carryover • 15,000 ML VEWH • 279,000 ML CEWH • 39,000 ML Living Murray • 358,000 ML total	• 25,000 ML carryover • 15,000 ML VEWH • 279,000 ML CEWH • 39,000 ML Living Murray • 358,000 ML total
Potential environmental watering – tier 1 (high priorities)[1]	• 1 Year-round low flows • 2 Spring fresh (partial) • 3a Increased year-round low flows (partial) • 3b Winter/spring variable low flows • 8 Provide a baseflow in reach 1 from May–September	• 1 Year-round low flows • 2 Spring fresh • 3a Increased year-round low flows (partial) • 3b Winter/spring variable low flows • 4 Autumn fresh (partial) • 8 Provide a baseflow in reach 1 from May–September	• 1 Year-round low flows • 2 Spring fresh • 3a Increased year-round low flows • 3b Winter/spring variable low flows • 4 Autumn fresh • Recession flow management • 8 Provide a baseflow in reach 1 from May–September	• 1 Year-round low flows • 3a Increased year-round low flows • 3b Winter/spring variable low flows • 4 Autumn fresh • 5 Winter fresh • Recession flow management • 8 Provide a baseflow in reach 1 from May–September
Potential environmental watering – tier 2 (additional priorities)[1]	• 2 Spring fresh (full) • 3 Increased year-round low flows (full) • 4 Autumn fresh • 5 Winter fresh • Recession flow management	• 3 Increased year-round low flows (full) • 4 Autumn fresh (full) • 5 Winter fresh • Recession flow management	• 5 Winter fresh	
Possible volume of water for the environment required to achieve objectives[2]	• 137,000 ML (tier 1) • 368,000 ML (tier 2)	• 280,000 ML (tier 1) • 249,000 ML (tier 2)	• 319,000 ML (tier 1) • 142,000 ML (tier 2)	• 344,000 ML (tier 1) • 0 ML (tier 2)
Critical carryover into 2019–20	• 0 ML	• 23,000 ML	• 0 ML	• 0 ML

[1] *The number preceding each potential environmental watering action align to the numbering in Table 5.4.2 above.*
[2] *Water for the environment requirements for tier 2 actions are additional to tier 1 requirements.*

Risk management

Environmental watering program partners have considered and assessed risks and identified mitigating strategies relating to environmental flows in 2018–19. Risks and mitigating actions are continually reassessed by program partners throughout the water year (see section 1.3.6).

5.4.2 Goulburn wetlands

Of some 2,000 natural wetlands in the Goulburn Broken area, only three in the Goulburn catchment (Reedy Swamp, Gaynor Swamp and Doctors Swamp) have been able to receive environmental water, through infrastructure connections to the river. Recent works to connect Loch Garry to the irrigation system will mean that it will also be possible to deliver water for the environment to Loch Garry from 2018–19, subject to the agreement of landowners. Loch Garry is a paleo channel (a remnant course) of the Goulburn River and the only wetland in the catchment that can receive water for the environment that has objectives for fish.

The Goulburn wetlands have been, and continue to be, places of significance for Traditional Owners and their Nations. The Registered Aboriginal Party (RAP) in the region is the Yorta Yorta Nation Aboriginal Corporation.

Environmental values

Many natural wetlands across the Goulburn catchment including Reedy Swamp, Loch Garry, Gaynor Swamp and Doctors Swamp are formally recognised for their conservation significance. The Goulburn wetlands support a variety of plant communities ranging from swamps dominated by river red gums to 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 and marsh sandpipers).

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

Gaynor Swamp is a cane grass wetland situated on paleosaline soils, and it can sometimes receive saline water from Lake Cooper during times of flood. When wet, Gaynor Swamp supports thousands of waterbirds including brolga and intermediate egrets. As Gaynor Swamp has a higher salt concentration than other wetlands in the region, 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 it is a drought refuge for eastern great egrets, musk ducks, nankeen night herons and royal spoonbills. Monitoring in 2012 recorded these four threatened waterbird species at Loch Garry.

Social and economic values

Visitor activities enjoyed at the Goulburn wetlands include birdwatching, picnicking, camping and walking. Duck hunting is allowed at Doctors Swamp and Gaynor Swamp, which are state game reserves, and at Loch Garry, which is a wildlife reserve.

Environmental watering objectives in the Goulburn wetlands

	Maintain and improve the range of native plant life including river red gum and grassy wetland species
	Provide feeding and breeding habitat for waterbirds including migratory and colonial nesting waterbirds
	Provide habitat for frog breeding
	Provide refuge in deep holes for large and small native fish

System overview

Gaynor Swamp, Reedy Swamp, Loch Garry and Doctors Swamp wetlands can all receive water for the environment via irrigation supply infrastructure in the Shepparton and Central Goulburn irrigation districts. The volume delivered at any one time depends on the available capacity in the irrigation supply network, and it may also be negotiated with adjacent landholders.

Reedy Swamp is naturally inundated when flow in the Goulburn River exceeds about 20,000 ML per day. Doctors Swamp can only receive water for the environment if the Cattanach Canal is running at 2,500 ML per day and there is available capacity after irrigation demand and operational requirements are met.

A structure to facilitate the delivery of water for the environment to Gaynor Swamp was constructed in February 2018, and the wetland received water for the environment for the first time in April 2018.

The newly constructed infrastructure connecting Loch Garry to the irrigation system will allow up to 20 ML per day of water for the environment to be delivered to Loch Garry. Loch Garry does not have a delivery share, so water for the environment can only be delivered when there is spare capacity to carry water in the channel.

Recent conditions

Natural inflows from high rainfall in the Goulburn catchment during December 2017 inundated all Goulburn wetlands, triggering the germination and reproduction of some wetland plants and providing habitat for waterbirds. Wetlands to the west of the Goulburn Broken catchment including Doctors Swamp and Gaynor Swamp received the highest rainfall, and Doctors Swamp filled.

Sloanes froglet, musk duck, hardheads and plumed whistling duck were recorded at Doctors Swamp following the natural filling. Fringed marshwort was prolific in the wetland, and billy-buttons grew around the fringes.

Gaynor Swamp was the only wetland to receive water for the environment in 2017–18. It received water for the environment in autumn 2018 for the first time, after drying from the heavy summer rainfall. The remaining wetlands have been inundated several times in the last few years and were therefore left to draw down naturally after the December event.

Scope of environmental watering

Table 5.4.4 shows potential environmental watering actions and their environmental objectives.

Table 5.4.4 Potential environmental watering actions and objectives for the Goulburn wetlands

Potential environmental watering	Environmental objectives
Doctors Swamp (fill in spring)	Maintain the diversity of wetland vegetation including cane grass Provide waterbird breeding and feeding habitat
Gaynor Swamp (fill in winter/spring)	Maintain the diversity of wetland vegetation including cane grass Provide waterbird breeding and feeding habitat
Loch Garry (fill in spring)	Increase the diversity of native wetland vegetation Maintain habitat for waterbird breeding Provide refuge pools for native fish
Reedy Swamp (fill in spring)	Increase the diversity of native wetland vegetation Maintain habitat for water breeding (particularly royal spoonbills and ibis)

Scenario planning

Table 5.4.5 outlines 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-dependant animals in the region at any point in time.

Maintaining a natural cycle of flooding and drying is important for the health of the wetlands. If Reedy Swamp remains dry over the winter of 2018, it will have reached its optimum drying period, and it will need watering in spring 2018.

Due to the natural flooding of Doctors Swamp (which remained wet until autumn 2018) and water for the environment delivered to Gaynor Swamp in autumn 2018, drying will be promoted at these wetlands. However, if significant target species (such as brolga) are found to be breeding before the wetland dries (or because of additional natural inflows), a spring/summer top-up may be necessary. If there are no natural inflows, Doctors Swamp and Gaynor Swamp will receive water for the environment in autumn 2019, to increase vegetation diversity and waterbird habitat.

Deliveries of water for the environment to Loch Garry cannot be guaranteed in 2018–19 because the agreement of landholders still needs to be negotiated.

Doctors Swamp on the regulator side, by Goulburn Broken CMA

Table 5.4.5 Potential environmental watering for the Goulburn wetlands under a range of planning scenarios

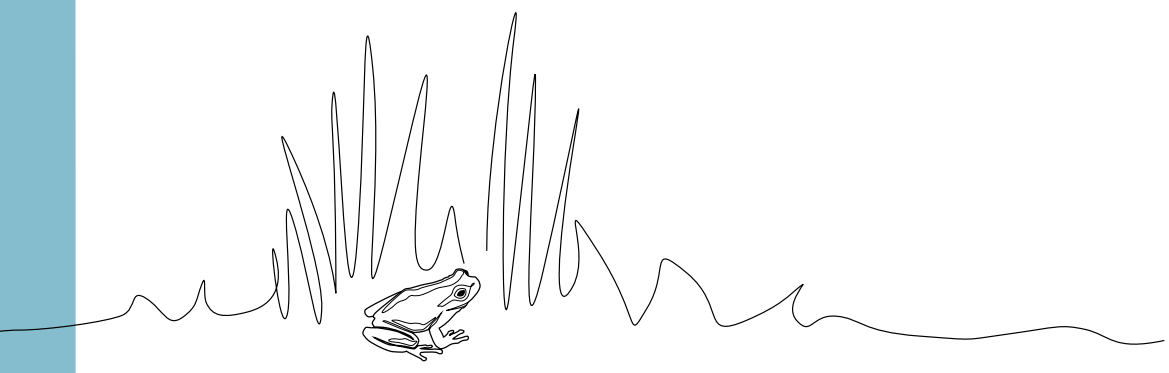
Planning scenario[1]	Drought	Dry	Average	Wet
Expected catchment conditions	• Catchment run-off and unregulated flows into the wetlands are highly unlikely	• Catchment run-off and unregulated flows into the wetlands are unlikely	• Some catchment run-off and unregulated flows into some of the wetlands are 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 1 (high priorities)	• Reedy Swamp	• Reedy Swamp	• Reedy Swamp	• Reedy Swamp
Potential environmental watering – tier 2 (additional priorities)	• Gaynor Swamp • Doctors Swamp • Loch Garry	• Gaynor Swamp • Doctors Swamp • Loch Garry	• Gaynor Swamp • Doctors Swamp • Loch Garry	• N/A
Possible volume of water for the environment required to achieve objectives[2]	• 500 ML (tier 1) • 1,500 ML (tier 2)	• 500 ML (tier 1) • 1,500 ML (tier 2)	• 500 ML (tier 1) • 750 ML (tier 2)	• 250 ML (tier 1)
Priority carryover requirements	• 2,000 ML	• 2,000 ML	• 1,250 ML	• 550 ML

[1] *If any of the wetlands support significant waterbird breeding events in spring/summer, deliveries of water for the environment may be considered to support bird habitat until fledging.*

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

Risk management

Environmental watering program partners have considered and assessed risks and identified mitigating strategies relating to environmental flows in 2018–19. Risks and mitigating actions are continually reassessed by program partners throughout the water year (see section 1.3.6).



5.5 Broken system

Waterway manager – Goulburn Broken Catchment Management Authority

Storage manager – Goulburn-Murray Water

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

The Broken system (including the Broken River, upper Broken Creek, lower Broken Creek and wetlands) supports threatened plant and animal species including six native fish species of Victorian and national conservation significance. The system also supports a range of habitats for waterbirds, especially cane grass wetlands that brolga rely on for feeding and breeding. The lower Broken Creek forms part of the irrigation network and receives water from the Murray and Goulburn systems.

Engagement

Table 5.5.1 shows the partners and stakeholder organisations with which the Goulburn Broken CMA engaged when preparing the Broken system seasonal watering proposal.

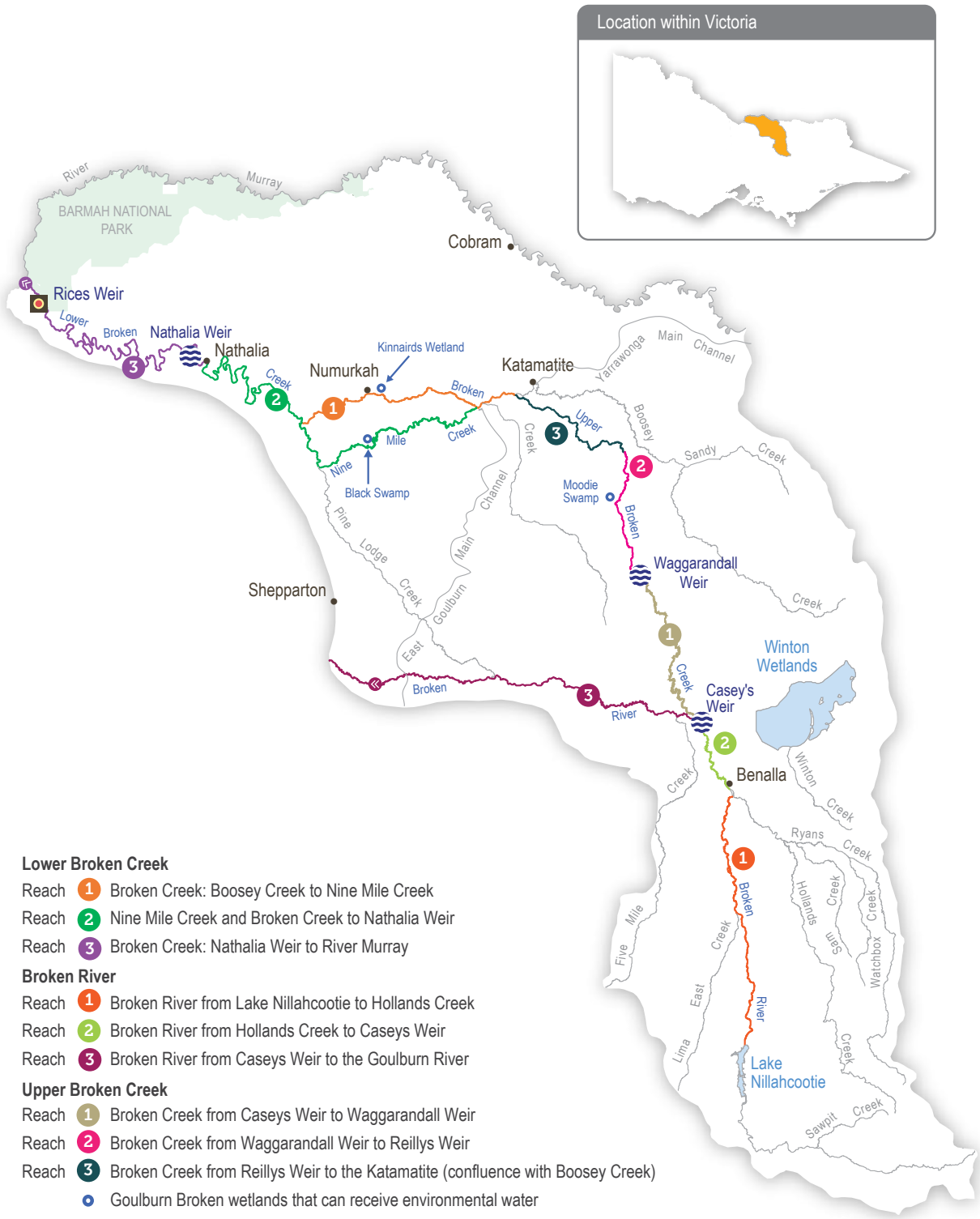
Seasonal watering proposals are informed by longer-term plans such as regional catchment strategies, regional waterway strategies and environmental water management plans and other studies. These plans incorporate a range of environmental, cultural, social and economic perspectives and longer term integrated catchment and waterway management objectives. For further details, refer to the *Goulburn Broken Regional Catchment Strategy* and *Goulburn Broken Waterway Strategy*.

Table 5.5.1 Partners and stakeholders engaged in developing the Broken system seasonal watering proposal

Partner and stakeholder engagement
• Broken Environmental Water Advisory Group (comprising community members)
• Commonwealth Environmental Water Office
• Goulburn Broken Catchment Wetland Advisory Group (with representation of Goulburn Valley Landcare, Field & Game Australia, Moira Shire, Greater Shepparton City Council, Turtles Australia, Parks Victoria, Trellys Fishing and Hunting and Kinnairds Wetland Advisory Committee)
• Goulburn-Murray Water
• Murray–Darling Basin Authority (River Murray Water)
• Parks Victoria
• Taungurung Clans Aboriginal Corporation
• Victorian Environmental Water Holder
• Yorta Yorta Nation Aboriginal Corporation

Flood marks on trees in Broken Creek, by Keith Ward, Goulburn Broken CMA

Figure 5.5.1 The Broken system



Lower Broken Creek

Reach 1 Broken Creek: Boosey Creek to Nine Mile Creek
Reach 2 Nine Mile Creek and Broken Creek to Nathalia Weir
Reach 3 Broken Creek: Nathalia Weir to River Murray

Broken River

Reach 1 Broken River from Lake Nillahcootie to Hollands Creek
Reach 2 Broken River from Hollands Creek to Caseys Weir
Reach 3 Broken River from Caseys Weir to the Goulburn River

Upper Broken Creek

Reach 1 Broken Creek from Caseys Weir to Waggarandall Weir
Reach 2 Broken Creek from Waggarandall Weir to Reillys Weir
Reach 3 Broken Creek from Reillys Weir to the Katamatite (confluence with Boosey Creek)

Goulburn Broken wetlands that can receive environmental water
Measurement point
Water infrastructure
Town
Indicates direction of flow

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.

5.5.1 Broken River and upper Broken Creek

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 irrigated agriculture. The main tributaries of the Broken River are Hollands Creek, Ryans Creek and Lima East Creek.

The upper Broken Creek is defined as the 89 km stretch of creek from Broken River (at Caseys Weir) to the Boosey Creek confluence near Katamatite. The creek is located on 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.

The Broken River and upper Broken Creek continue to be places of importance for Traditional Owners and their Nations. The Registered Aboriginal Parties (RAPs) in the Broken catchment are the Yorta Yorta Nation Aboriginal Corporation and the Taungurung Clans Aboriginal Corporation. Representatives from both RAPs were engaged during the preparation of Broken River and upper Broken Creek seasonal watering proposals.

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 populate the bed and margins of the river including eelgrass, common reed and water ribbons. 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, and 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. It contains high-quality native vegetation, much of which is set aside as a natural features reserve. The creek supports a variety of threatened animals including fish species (such as the 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 as on the *Directory of Important Wetlands in Australia*.

Social and economic values

The Broken River and associated wetland and floodplain habitats support a range of recreational and tourism values, and they provide opportunities for bushwalking, boating, fishing and birdwatching. The waterways are an important source of water and a delivery mechanism for some stock and domestic and irrigation customers.

Environmental watering objectives in the Broken River and upper Broken Creek systems

	Mobilise built-up sand and clay material to restore deep pools and provide habitat for aquatic animals
	Improve in-stream and riparian vegetation
	Enhance native fish populations including threatened Murray cod and golden perch by improving pool habitat and encouraging fish migration and spawning
	Maintain water quality
	Support a wide range and high biomass of waterbugs to break down dead organic matter and support the river's food web
	Maintain platypus populations and provide conditions for successful breeding

System overview

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 largely natural flow pattern due to the contribution of tributary inflows. The catchment has been extensively cleared for agriculture including dryland (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 the dam may be less than 30 ML per day as tributary inflows immediately below the dam (such as from Back Creek) can supply much of minimum-flow requirements specified in the bulk entitlement.

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 now influenced by rainfall and catchment run-off and environmental deliveries to Moodie Swamp. These changes have reduced the amount of permanent aquatic habitat, which can be increased by deliveries of water for the environment.

Delivery of water for the environment down the Broken River is primarily constrained by the availability of water. In most cases, the water for the environment available is much less than the volume required to deliver the desired flow components. Deliveries of water for the environment in upper Broken Creek are primarily restricted by channel capacity, to avoid flooding adjacent land.

Recent conditions

Flows in the Broken River between June 2017 and March 2018 met minimum-flow requirements. High-rainfall events delivered natural freshes via tributary inflows in winter, spring and summer, with peak discharges between 300 ML per day and 4,500 ML per day in the lower reaches (reach 3). Reach 1 received less water from tributaries and therefore had fewer freshes compared with downstream reaches. A large storm in early December 2017 generated an event with a peak discharge of 1,800 ML per day from Lake Nillachootie, which was the only natural fresh in reach 1 for the year. Water for the environment was used to deliver another fresh of 300 ML per day to reach 1 in autumn 2018. It was the first time an environmental flow had been delivered in the Broken River to meet environmental objectives.

Flows in the upper Broken Creek between June 2017 and March 2018 met minimum winter/spring flow requirements most of the time, while summer/autumn minimum-flow requirements were met less than half of the time. Four small, natural freshes occurred in winter, spring and summer, with peak discharges between 20 ML per day and 40 ML per day. This would have flooded a small proportion of the floodplain in reach 2 downstream of Waggarandall Weir. In autumn 2018, deliveries of water for the environment to Moodie Swamp helped meet the minimum-flow recommendation of 5 ML per day at Waggarandall Weir.

Scope of environmental watering

Table 5.5.2 shows potential environmental watering actions and their environmental objectives.

Table 5.5.2 Potential environmental watering actions and objectives for the Broken River and upper Broken Creek system

Potential environmental watering	Environmental objectives
Summer/autumn fresh in upper Broken Creek (1 fresh of up to 50 ML/day for 10 days in December–May)	• Maintain water quality, particularly in refuge pools
Summer/autumn low flows in upper Broken Creek (up to 5 ML/day for 30–60 days in December–May)	• Maintain habitat for native fish populations and waterbugs • Maintain platypus habitat • Maintain in-stream vegetation
Winter/spring low flows in upper Broken Creek (up to 10 ML/day for 30–60 days in June–November)	• Maintain habitat for native fish populations and waterbugs • Support successful platypus breeding • Maintain in-stream vegetation
Year-round low flows in the Broken River (up to 15 ML/day for 40–100 days)	• Maintain hydraulic habitat for native fish, aquatic plants and waterbugs
Summer/autumn freshes in the Broken River (1 fresh of 400–500 ML/day for 2–5 days in December–May)	• Scour sediment around large wood and turn over bed sediments • Provide flow cues to stimulate native fish breeding and migration • Replenish biofilms and increase productivity • Maintain habitat for aquatic plants • Maintain longitudinal connectivity for native fish passage

Scenario planning

Table 5.5.3 outlines the potential environmental watering and expected water use under a range of planning scenarios.

Requirements for water for the environment 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. Environmental flow management aims to allow catchment run-off and water system operation to meet as many flow recommendations as possible. Where possible, water from environmental entitlements will be used 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. Flow targets in upper Broken Creek are less likely to be met by catchment run-off and managed releases, and a lack of flow in the creek poses a significant risk to native fish, platypus and macroinvertebrate populations. Low flows and water-quality freshening flows are planned throughout the year.

Once the requirements of upper Broken Creek have been met, any remaining water for the environment may be used in the Broken River. Minimum baseflows are planned to be maintained if not met through irrigation releases or catchment run-off, as well as a fresh immediately downstream of Lake Nillahcootie after the end of the irrigation season, if there is little catchment run-off.

Table 5.5.3 Potential environmental watering for the Broken River and upper Broken Creek system 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 during 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[1]	• 0–267 ML	• 534 ML		
Potential environmental watering	• Summer/autumn fresh in upper Broken Creek • 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 • 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 Broken River	• Summer/autumn fresh in upper Broken Creek • Summer/autumn low flows in upper Broken Creek • Winter/spring low flows in upper Broken Creek • Summer/autumn fresh in Broken River	• Summer/autumn fresh in upper Broken Creek
Possible volume of water for the environment required to achieve objectives	• 1,500–2,000 ML	• 1,090–5,500 ML	• 890–5,300 ML	• 0–1,000 ML

[1] *Water for the environment may be traded into the Broken system to increase supply, subject to trade rules.*

Risk management

Environmental watering program partners have considered and assessed risks and identified mitigating strategies relating to environmental flows in 2018–19. Risks and mitigating actions are continually reassessed by program partners throughout the water year (see section 1.3.6).

5.5.2 Lower Broken Creek

Lower Broken Creek is the section of Broken Creek that flows from the confluence with Boosey Creek near Katamatite to the River Murray near Barmah. Nine Mile Creek is an anabranch that leaves lower Broken Creek at the East Goulburn Main Channel and rejoins it downstream of Numurkah. Both waterways are collectively referred to as the lower Broken Creek.

The lower Broken and Nine Mile creeks and associated floodplain continue to be an important place for Traditional Owners and their Nations. The RAP for this system is the Yorta Yorta Nation Aboriginal Corporation, who were involved in preparing the lower Broken Creek seasonal watering proposal.

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 features reserve. The associated floodplain and wetland habitats support box-dominated grassy woodland communities and numerous threatened species of state and national conservation significance including river swamp wallaby-grass and the Australasian bittern.

Social and economic values

The lower Broken and Nine Mile creeks and associated floodplain and wetland habitats provide water for agriculture and urban centres and support a variety of recreational activities (such as fishing and bushwalking).

Environmental watering objectives in the lower Broken Creek

	Control excessive build-up of azolla, which is a native aquatic plant that can lower water quality in the creek when significant blooms occur
	Protect and increase populations of native fish including the threatened Murray cod, golden perch and silver perch by maintaining habitat (water level and quality), allowing fish passage and stimulating fish to migrate and spawn
	Maintain healthy water oxygen levels

System overview

The lower Broken and Nine Mile creeks have been regulated for over a century, significantly altering their flow regimes. Pre-regulation, the creeks would have mainly flowed in winter and spring and the adjacent floodplain would have received more-regular flooding from overbank flows. In summer and autumn, the creeks would have had much less flow, often contracting to isolated pools or drying out completely. The creeks now have numerous weirs and flow at a relatively constant level from mid-August until mid-May to support adjacent irrigated farming. 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 or flush azolla as necessary.

The lower Broken Creek is operated separately to the upper Broken Creek and 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 priority river reach for environmental watering is reach 3 (from Nathalia Weir Pool to the River Murray), as it supports the best fish community and is where water quality deteriorates first in warmer months. Environmental flows that target reach 3 are expected to also deliver the desired flows in reaches 1 and 2. The measurement point for environmental flows in the lower Broken Creek is at Rices Weir.

Environmental targets can also be met by water delivered from Lake Eildon (known as inter-valley transfers) or Hume Reservoir (known as choke bypass flows) to meet downstream consumptive demands in the River Murray. These consumptive deliveries occur usually during peak irrigation demand, occurring from spring to autumn. These flows may help achieve the desired environmental objectives without the need to release environmental water.

Recent conditions

A dry winter and spring in 2017 meant there was little unregulated flow in the lower Broken Creek, so water for the environment was used to maintain target flows. A winter low flow was delivered before higher flushing flows in August and September 2017, which were delivered to break up and move azolla, which blanketed over 2 km of the creek in several locations. A combination of weir pool manipulation and physically disrupting the azolla significantly reduced the amount of azolla and prevented a further build-up. Hot weather in October 2017 caused much of the remaining azolla to shrink and die, and higher flows that were delivered to provide fish passage helped to break up the remaining blockages and flush the azolla from the system.

In response to a large rainfall event forecast in early December 2017, water levels in the Murray Valley irrigation channels were lowered by increasing outfalls into the lower Broken Creek. The outfalls increased flow in the creek above 700 ML per day for a short period.

Water for the environment was used to maintain dissolved oxygen levels in the lower Broken Creek through summer. Between January and March 2018, average daily flow past Rices Weir was reasonably steady, with a combination of environmental flow releases and Goulburn inter-valley transfer deliveries maintaining target flow rates.

A recent fish population survey in the lower Broken Creek indicates natural spawning and recruitment is occurring and that reaches with a high density of submerged wood, which provides fish habitat, have the highest abundance of native fish. Murray cod larvae were recorded in the creek for the first time, and adult golden perch were abundant. The lack of juvenile golden perch and the detection of golden perch movement in response to increases in flow and water temperature in spring support the theory that the population is primarily maintained by migration from the River Murray. Murray cod were detected moving throughout the lower Broken Creek system during late winter and spring, which highlights the benefit of delivering environmental flows outside of the irrigation season.

Scope of environmental watering

Table 5.5.4 shows potential environmental watering actions and their environmental objectives.

Table 5.5.4 Potential environmental watering actions and objectives for the lower Broken Creek

Potential environmental watering	Environmental objectives
Year-round low flows (40 ML/day)[1]	• Provide native fish passage through fish ladders
Winter/spring low flows (120 ML/day in August–November)	• Minimise azolla growth
Spring/summer/ autumn low flows (150–250 ML/day in October–May)	• Minimise azolla build-up • Maintain dissolved oxygen above 5 mg/L
Winter/spring freshes (up to 500 ML/day in August–November)	• Manage azolla blooms • Trigger fish migration
Spring/summer low flows (250 ML/day in September–December)	• Increase the availability of native fish habitat during the migration and breeding seasons

[1] *Primarily planned for the irrigation season between mid-August and mid-May, but it may be delivered year-round subject to supply constraints.*

Scenario planning

Table 5.5.5 outlines the potential environmental watering and expected water usage 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, water for the environment needs in these creeks are relatively fixed from year to year and independent of annual climatic conditions.

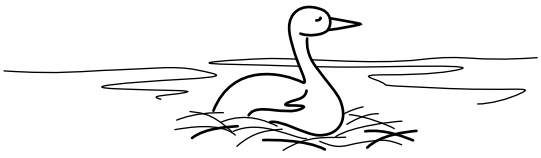
During 2018–19, environmental flows in the lower Broken Creek will be adjusted as needed to maximise the quantity of habitat and movement opportunities for native fish, maintain water quality and flush azolla through the system. The environmental flow objectives may be partly or wholly met by regulated 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 provide higher flows because irrigation demand and the associated consumptive water flows are likely to meet many of the environmental low-flow requirements. During wet conditions, there will be less demand for consumptive water and therefore more water for the environment may be needed to meet the low-flow requirements.

Table 5.5.5 Potential environmental watering for the lower Broken Creek under a range of planning scenarios

Planning scenario	Drought to dry	Average	Wet
Expected river conditions	• Some unregulated flows in winter • No unregulated flows throughout the irrigation season (mid-August–May) • No diversion of unregulated River Murray flows available	• Unregulated flows in winter/spring • No unregulated flows from October–May • Diversion of unregulated River Murray flows available mid-August–October	• Unregulated flows in winter/spring • No unregulated flows from November–May • Diversion of unregulated River Murray flows available mid-August–November
Potential environmental watering	• Year-round low flows • Winter/spring low flows • Spring/summer/autumn low flows • Winter/spring freshes • Spring/summer low flows		
Possible volume of water for the environment required to achieve objectives	• 56,480 ML	• 54,470 ML	• 57,580 ML

Risk management

Environmental watering program partners have considered and assessed risks and identified mitigating strategies relating to environmental flows in 2018–19. Risks and mitigating actions are continually reassessed by program partners throughout the water year (see section 1.3.6).



5.5.3 Broken wetlands

Of some 2,000 natural wetlands in the Goulburn Broken area, only three in the Broken catchment have infrastructure that connect them to receive environmental water: Black Swamp, Kinnairds Wetland and Moodie Swamp. Kinnairds Wetland (96 ha) and Black Swamp (16.5 ha) are red gum swamps near Numurkah. Moodie Swamp is a 180 ha cane grass wetland adjacent to Broken Creek at Waggarandall that provides excellent breeding habitat for brolga.

Wetlands in this region continue to be important places for Traditional Owners and their Nations. The Registered Aboriginal Parties (RAP) in the region are the Yorta Yorta Nation Aboriginal Corporation and the Taungurung Clans Aboriginal Corporation. Representatives from the RAPs were engaged during the preparation of the Broken wetlands seasonal watering proposal.

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, spoonbill, Australasian shoveler and glossy ibis). Many of these species are listed in international agreements and conventions.

Social and economic values

The wetlands support a range of recreational activities including birdwatching, bike riding, bushwalking and camping. Moodie Swamp and Black Swamp are state game reserves managed by Parks Victoria. Kinnairds Wetland is managed by Moira Shire and Goulburn-Murray Water.

Environmental watering objectives in the Broken wetlands

	Maintain or improve the diversity of wetland vegetation Maintain populations of nationally threatened plant species (such as ridged water milfoil, slender water milfoil and river swamp wallaby-grass)
	Maintain feeding and breeding habitat for waterbirds, particularly for brolga, royal spoonbill and Australasian shoveler

System overview

The water regimes of these wetlands have been greatly 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, to restore some of the natural wetting and drying patterns. However, the lack of channel capacity share restricts the ability to deliver the required volume of water for the environment to the wetlands when it is most needed.

Recent conditions

The Broken River catchment received near-average rainfall early in the 2017–18 water year, followed by a drier-than-average summer and autumn. The main exception was a storm in early December 2017 that dropped more than three times the average December rainfall in a few days. Run-off from the storm and associated flooding delivered some inflows to Black Swamp, Kinnairds Wetland and Moodie Swamp.

Black Swamp and Kinnairds Wetland filled naturally in spring 2016, and they were not actively watered in 2017–18, to support the natural wetting and drying cycles. Periodic drying of wetlands is important to allow newly germinated wetland plants to grow and set seed following extended wet phases. The December 2017 storm delivered only small inflows to both wetlands, which lasted less than three months and which did not significantly disrupt the drying phase.

Moodie Swamp also filled in spring 2016 and received some inflows in December 2017. Water for the environment was delivered to Moodie Swamp in autumn 2018 to promote cane grass habitat, priming the wetland for brolga breeding.

Scope of environmental watering

Table 5.5.6 shows potential environmental watering actions and their environmental objectives.

Table 5.5.6 Potential environmental watering actions and objectives for the Broken wetlands

Potential environmental watering	Environmental objectives
Black Swamp (fill in spring)	• Maintain the diversity of wetland vegetation • Provide waterbird feeding and breeding habitat
Kinnairds Wetland (fill in spring)	• Maintain the diversity of wetland vegetation • Maintain populations of the nationally threatened ridged water milfoil and slender water milfoil • Provide waterbird feeding and breeding habitat
Moodie Swamp (fill in autumn)	• Maintain the diversity of wetland vegetation • Maintain populations of the nationally threatened ridged water milfoil and slender water milfoil • Provide waterbird feeding and breeding habitat, particularly for brolga

Scenario planning

Table 5.5.7 outlines 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.

Kinnairds Wetland and Black Swamp have been identified as high priorities in all planning scenarios, as neither wetland received significant volumes of water in 2017–18. Both wetlands provide important habitat for waterbirds and wetland vegetation communities including ridged water milfoil, water nymph and river swamp wallaby-grass.

Moodie Swamp received water for the environment in autumn 2018. It will hold water over winter (when brolga are breeding), then be left to draw down slowly in spring, allowing newly germinated wetland plants to grow and set seed. Water for the environment may be delivered to top-up Moodie Swamp in late summer if waterbirds are breeding.

In a typical wet scenario, all three wetlands will fill naturally in winter or spring, and only small volumes of water for the environment may be required to extend the duration or extent of natural flooding to support a significant waterbird breeding event if it occurs.

A magpie goose and yellow-billed spoonbills at Black Swamp, by Goulburn Broken CMA

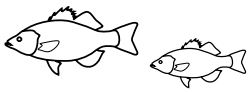
Table 5.5.7 Potential environmental watering for the Broken wetlands under a range of planning scenarios

Planning scenario	Drought	Dry	Average	Wet
Expected catchment 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 flows into some of the wetlands are likely, particularly in winter/spring	• Catchment run-off and unregulated flows into the wetlands may partly or wholly fill the wetlands, particularly in winter/spring
Potential environmental watering – tier 1 (high priorities)	• Black Swamp (spring) • Kinnaird Wetland (spring)	• Black Swamp (spring) • Kinnaird Wetland (spring)	• Black Swamp (spring) • Kinnaird Wetland (spring)	• Black Swamp (spring) • Kinnaird Wetland (spring)
Potential environmental watering – tier 2 (additional priorities)	• Moodie Swamp (autumn)	• Moodie Swamp (autumn)	• Moodie Swamp (autumn)	
Possible volume of water for the environment required to achieve objectives[1]	• 580 ML (tier 1) • 500 ML (tier 2)	• 580 ML (tier 1) • 500 ML (tier 2)	• 580 ML (tier 1) • 250 ML (tier 2)	• 300 ML (tier 1)

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

Risk management

Environmental watering program partners have considered and assessed risks and identified mitigating strategies relating to environmental flows in 2018–19. Risks and mitigating actions are continually reassessed by program partners throughout the water year (see section 1.3.6).



5.6 Campaspe system

Waterway manager – North Central Catchment Management Authority

Storage managers – Goulburn-Murray Water, Coliban Water

Environmental water holders – Victorian Environmental Water Holder, Commonwealth Environmental Water Holder, the Murray–Darling Basin Authority (the Living Murray program)

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.

The catchment supports important populations of plants and animals, particularly platypus and native fish. Platypus are a feature of both the Campaspe and Coliban rivers, and the recovery of native fish in the Campaspe River below Lake Eppalock remains a key objective.

Engagement

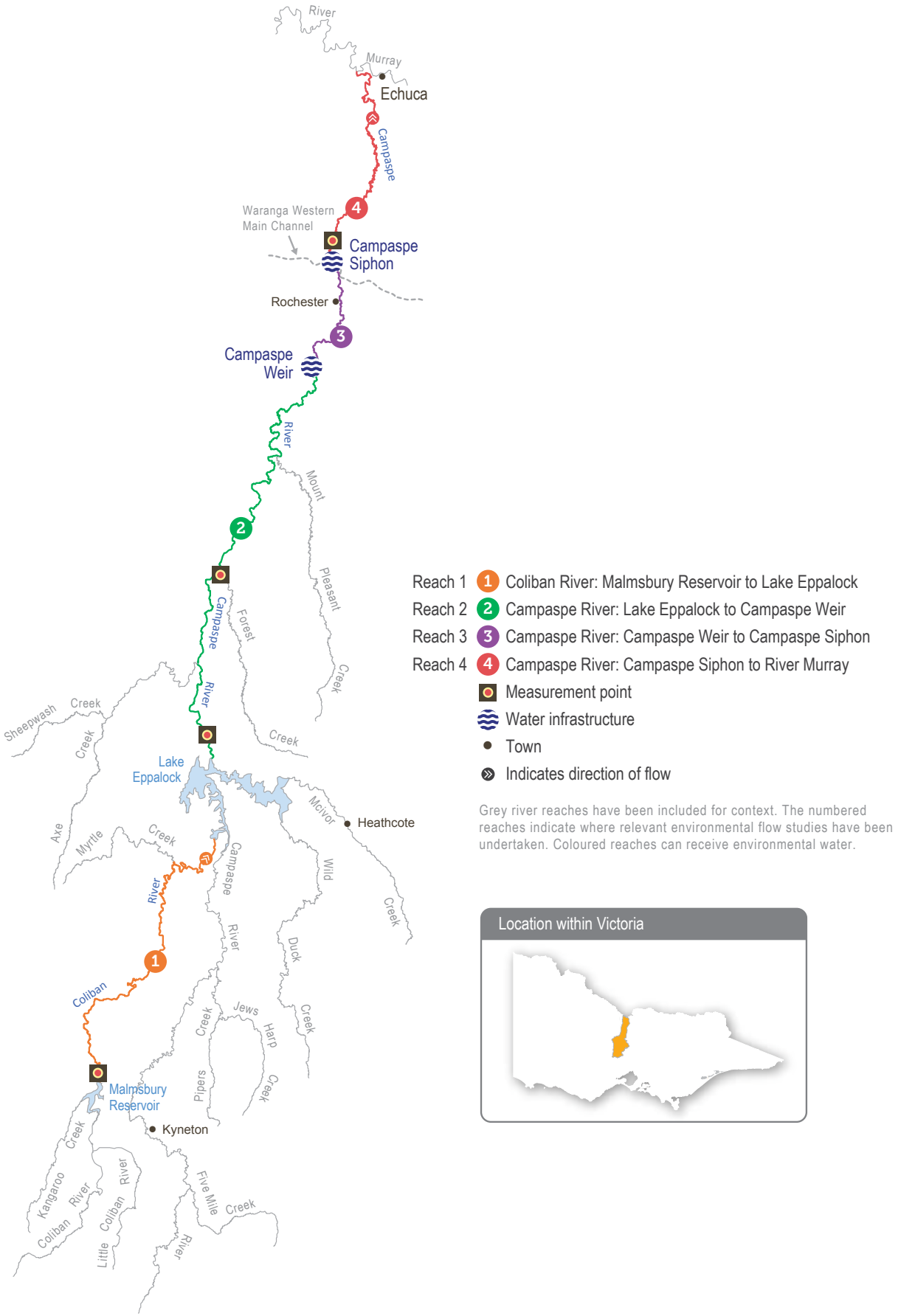
Table 5.6.1 shows the partners and stakeholder organisations the North Central CMA engaged in preparing the Campaspe system seasonal watering proposals.

Seasonal watering proposals are informed by longer-term regional catchment strategies, regional waterway strategies, environmental flow studies, water management plans and other studies. These incorporate a range of environmental, cultural, social and economic perspectives and longer-term integrated catchment and waterway management objectives. For further details, refer to the *North Central Regional Catchment Strategy* and the *North Central Waterway Strategy.*

Table 5.6.1 Partners and stakeholders engaged in developing the Campaspe system seasonal watering proposals

Partner and stakeholder engagement
• Campaspe Environmental Water Advisory Group (comprising community members, Department of Environment, Land, Water and Planning, Goulburn-Murray Water, North Central CMA, the Victorian Environmental Water Holder and the Commonwealth Environmental Water Office)
• Coliban Water
• Dja Dja Wurrung Clans Aboriginal Corporation
• Dja Dja Wurrung Traditional Owners
• Taungurung Clans Aboriginal Corporation
• Yorta Yorta Nation Aboriginal Corporation

Figure 5.6.1 The Campaspe system



5.6.1 Campaspe River

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 not used for water diversion now, 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.

The Campaspe River continues to be an important place for Traditional Owners and their Nations. The Registered Aboriginal Parties (RAPs) in the region are the Taungurung Clans Aboriginal Corporation, the Dja Dja Wurrung Clans Aboriginal Corporation and the Yorta Yorta Nation Aboriginal Corporation. Representatives from the three RAPs were engaged during the preparation of the Campaspe system seasonal watering proposal.

The Campaspe River has been identified as a priority for restoration under *Water for Victoria*. The Caring for the Campaspe project will deliver revegetation and fencing projects to protect and improve riparian land along the Campaspe River and its tributaries. Complementary water management activities such as these are needed to optimise the environmental outcomes achievable with environmental flows.

Environmental values

The Campaspe River below Lake Eppalock provides important habitat for several native fish species including Murray cod, silver perch, golden perch, Murray-Darling rainbowfish and flat-headed gudgeon. Notably the Murray-Darling rainbowfish, a listed species in Victoria and previously presumed lost from the system, has recently been recorded at many sites on the Campaspe River and is now abundant downstream of Elmore.

Maintaining flows is important for migration opportunities and dispersal of these fish species. Platypus, water rats, turtles and frogs are also present along the length of the 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).

Social and economic values

The Campaspe River is an important source of water and a delivery mechanism for irrigation, industry and town water (including to Bendigo and Ballarat). Popular recreational activities along the Campaspe River include camping, boating, kayaking, fishing, swimming, bushwalking, picnicking and birdwatching. These activities draw locals and tourists alike, providing economic benefit to towns along the river.

Environmental watering objectives in the Campaspe River

	Sustain adult river red gums and provide opportunities for successful recruitment Maintain the extent and increase the diversity of riparian vegetation Maintain or increase the extent of in-stream aquatic plants
	Provide habitat to help protect and increase populations of native fish Help native fish species (such as the trout cod, river blackfish and Macquarie perch) recolonise the river
	Maintain resident platypus population by providing places to rest, breed and feed, as well as opportunities for juveniles to disperse
	Provide connection along the length of the Campaspe River and into the River Murray
	Increase the diversity and biomass of waterbugs to provide energy, break down dead organic matter and support the river's food chain
	Prevent high salinity and maintain healthy levels of oxygen in deep pools

System overview

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.

Regulation of the river has significantly reduced flows and reversed seasonal patterns, so that flows in most years are now higher during the summer and autumn irrigation season and lower in winter and spring. Lake Eppalock also captures many of the bankfull and overbank flow events that would naturally have passed through the system.

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 periods. Primary flow measurement points are at Barnadown (reach 2) and downstream of the Campaspe Siphon (reach 4).

Goulburn-Murray Water transfers consumptive water from Lake Eppalock to customers in the River Murray or to downstream storages (such as Lake Victoria). These inter-valley transfers usually occur in summer/autumn and can significantly increase flows in the Campaspe River at a time when flows would naturally be low. These high 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 these transfers may have on native plants and animals. For example, inter-valley transfers 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.

Recent conditions

Rainfall and climate conditions in the region were largely drier and hotter than the long-term average throughout 2017–18. There were few unregulated flows from tributaries, and Lake Eppalock did not spill. The dry conditions led to high consumptive water demand in the Murray and Goulburn systems. Large volumes of inter-valley transfers were delivered from the Campaspe system to meet these demands, and despite the dry season flows in the Campaspe River was equivalent to wet-to-very-wet conditions in summer/autumn. For much of summer, flows in the Campaspe River were close to an order of magnitude greater than recommended for environmental purposes. Managers worked with ecologists to provide advice to storage managers to minimise risks to environmental values throughout this period.

The Campaspe River received several planned environmental flows events in 2017–18. Flows were provided with a combination of passing flows, consumptive water delivery and managed releases of water for the environment. Winter low flows were delivered between July and November 2017, with small, unregulated tributary flows providing additional variation. Two freshes were delivered during spring to trigger fish movement and spawning and to improve vegetation condition and the water quality and productivity of the aquatic ecosystem. The first fresh in early September 2017 reached 1,200 ML per day for two days. The second fresh was delivered as two consecutive peaks (of 1,400 ML per day for two days and 1,600 ML per day for two days) to encourage golden perch spawning. The summer inter-valley transfers were shaped to attract juvenile golden and silver perch from the River Murray into the Campaspe system. This event builds on the success of a similar event in the previous year.

Monitoring of native fish and vegetation continued in the Campaspe River in 2017–18. Highlights include the first-detected Murray cod larvae since regular monitoring began and the detection of silver perch at more than half of the sites surveyed in reaches 3 and 4. Monitoring showed continued recovery of the vegetation after the Millennium Drought and bank-scouring floods of 2010-11, and five Victorian rare or threatened species including the small scurf-pea were detected.

Scope of environmental watering

Table 5.6.2 shows potential environmental watering actions and their environmental objectives.

Table 5.6 2 Potential environmental watering actions and objectives for the Campaspe River

Potential environmental watering	Environmental objectives
Summer/autumn low flows (10–50 ML/day in December–May)	• Provide permanent connectivity to maintain water quality, particularly dissolved oxygen and salinity levels
Winter/spring low flows (50–200 ML/day in June–November)	• Maintain connectivity of pool refuges for fish and improved habitat for water bugs • Maintain connectivity to prevent a decline in water quality
Winter/spring freshes (2 events at 1,000–1,800 ML/day for up to 7 days each in June–November)	• Stimulate fish movement, allow movement to downstream reaches and provide spawning triggers • Water riparian vegetation • Maintain habitat for waterbugs • Support platypus habitat and breeding opportunities including triggers for burrow selection • Flush organics from bank and benches to reduce the risk of blackwater events in summer
Summer/autumn freshes (up to 3 freshes of 50–200 ML/day for up to 3 days each in December–May)	• Provide longitudinal connectivity for fish in periods of low flow • Maintain habitat for waterbugs • Maintain water quality

Scenario planning

Table 5.6.3 outlines the potential environmental watering and expected water usage under a range of planning scenarios.

Planning for the use of water for the environment in the 2018–19 season is based on three identified management scenarios. Each scenario is based on expected operational river flows from Goulburn-Murray Water, unregulated flows from rainfall events and water for the environment available in the Campaspe River system.

The three scenarios have been developed in line with the historic inflow records for the Campaspe River and are the critical decision points for delivery of water for the environment. These decisions are based on the likely volume of water available and the critical-flow components required in a season. The intention of the scenario planning approach is to build the flexibility required to adjust to seasonal circumstances as they unfold throughout the year, to achieve the planned ecological objectives for 2018–19.

If additional water becomes available during the year, the number and size of events can be increased. This would provide improved conditions for plants and animals, which helps strengthen populations while conditions are good. Carryover into 2019–20 is not a priority this year, with allocation available on 1 July 2019 from a very high-reliability component of the environmental entitlement, which will meet minimum critical demands.

Table 5.6.3 Potential environmental watering for the Campaspe River under a range of planning scenarios

Planning scenario	Drought	Dry	Average to wet
Expected river conditions	• Few or no unregulated flows • High consumptive water deliveries • No passing flows in winter • No spills from storage	• Some unregulated flows • Some consumptive water deliveries • Increased passing flows • Some unregulated flows from storage spill	• Frequent unregulated flows • Moderate summer consumptive water deliveries in reach 2 and low deliveries in reaches 3 and 4 in summer • Increased passing flows • Significant spills from storage
Expected availability of water for the environment	• 20,652 ML VEWH • 6,594 ML CEWH • 126 ML Living Murray • 6,000 ML carryover • 33,372 ML total	• 20,652 ML VEWH • 6,594 ML CEWH • 126 ML Living Murray • 3,000 ML carryover • 30,372 ML total	• 20,652 ML VEWH • 6,594 ML CEWH • 126 ML Living Murray • 0 ML carryover • 27,372 ML total
Potential environmental watering – tier 1 (high priorities)	• Summer/autumn low flow • Winter/spring low flow • Winter/spring fresh (1 event) • Summer/autumn freshes (3 events) • 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 freshes (1 event) • Summer/autumn freshes (3 events) • 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 freshes (2 events) • Summer/autumn freshes (3 events) • Additional freshes may be required to avoid critical loss of species/habitat if a low-dissolved-oxygen event occurs
Potential environmental watering – tier 2 (additional priorities)	• Increased magnitude of winter/spring low flow • Winter/spring fresh (1 additional event) • Increased magnitude of summer/autumn freshes • Provide fish-attracting flows in summer	• Increased magnitude of winter/spring low flow • Winter/spring fresh (1 additional event) • Increased magnitude of winter/spring and summer/autumn freshes • Provide fish-attracting flows in summer	• Increased magnitude of winter/spring low flow • Increased magnitude of winter/spring and summer/autumn freshes • Provide fish-attracting flows in summer
Possible volume of water for the environment required to achieve objectives[1]	• 28,800 ML (tier 1) • 25,200 (tier 2)	• 30,000 ML (tier 1) • 28,800 ML (tier 2)	• 27,200 ML (tier 1) • 28,000 ML (tier 2)

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

Risk management

Environmental watering program partners have considered and assessed risks and identified mitigating strategies relating to environmental flows in 2018–19. Risks and mitigating actions are continually reassessed by program partners throughout the water year (see section 1.3.6).

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.

The Coliban River continues to be an important place for Traditional Owners and their Nations. The Registered Aboriginal Party in the region is the Dja Dja Wurrung Clans Aboriginal Corporation who were engaged during the preparation of the Coliban seasonal watering proposal.

Environmental values

The Coliban River provides important habitat for platypus, native 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 streambank shrubland vegetation and woodland containing river red gum, callistemon, woolly tea-tree and inland wirilda, which provide habitat for terrestrial animals.

Social and economic values

Communities in Malmsbury, Taradale, Metcalfe and the surrounding area value the Coliban River for its aesthetic and recreational features including Ellis Falls and the Cascades. Popular recreational activities in the area include camping, fishing and birdwatching. The upper Coliban storages – the Malmsbury and Lauriston reservoirs – supply urban, irrigation, stock and domestic demands in the surrounding area.

Environmental watering objectives in the Coliban system

	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 adult riparian vegetation and provide opportunities for recruitment
	Increase the abundance and diversity of small-bodied native fish by providing flows that allow movement
	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
	Support platypus communities by providing opportunities for successful breeding and dispersal
	Clean fine sediment from substrates to support biofilms

System overview

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 to help mitigate some risks associated with critically low summer 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 2018–19.

Recent conditions

Rainfall in the Coliban River area for the 2017–18 season has been variable although generally below average. Rainfall between August and November is essential for filling the Coliban storages. Rainfall between August and November 2017 was 165 mm, which is slightly less than the long-term average of 191 mm. For most of the year, there was little-to-no contribution of unregulated flows from catchment run-off, so flows in the Coliban River were generally well-below environmental flow recommendations. The exception was a small spill from Malmsbury Reservoir in September.

Passing flows were reduced to 4 ML per day during winter/spring to enable managers to build a reserve in the Malmsbury passing flows account that could be used to maintain continuous flows in the upper reaches over summer: otherwise, flows would stop completely. Even with the release of accumulated passing flows, the lowest reaches of the Coliban River contracted to a series of isolated pools in summer/autumn.

Scope of environmental watering

Table 5.6.4 shows potential environmental watering actions and their environmental objectives.

Table 5.6.4 Potential environmental watering actions and objectives for the Coliban system

Potential environmental watering	Environmental objectives
Pulsed summer/ autumn low flow (5–15 ML/day for up to 2 weeks in December–May as required)[1]	• Maintain water quality (including dissolved oxygen levels) and habitat for aquatic biota (including fish and platypus)
Summer/autumn low flow (1–10 ML/day in December–May)	• Maintain water quality (including dissolved oxygen levels) and habitat for aquatic animals (including fish and platypus) • Maintain aquatic and fringing vegetation • Maintain waterbug habitat
Summer/autumn freshes (2 events of up to 200 ML/day for 3 days in December–May)[1]	• Support fish and platypus movement during the summer period • Maintain aquatic and fringing vegetation • Improve water quality and waterbug habitat • Flush organics and sediment from in-stream substrates

[1] *The actual volume and duration of freshes will depend on available water resources, climatic conditions and conditions within the river.*

Scenario planning

Table 5.6.5 outlines the potential environmental watering and expected water usage under a range of planning scenarios. There is insufficient water available to meet all the requirements for water for the environment of the Coliban system and managers must prioritise actions on an annual basis.

Water availability in the Coliban system relies on withholding passing flows in winter/spring for use in the high-risk summer period when poor water quality is more likely. Providing constant low flows and short freshes can maintain habitat in the section immediately downstream of Malmsbury Reservoir.

The volume of water available varies based on inflows, storage spills and the volume of passing flows accumulated. Less water is available in dry years or following a spill from storage. 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 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 incident and the amount of flow and water in the river at the time.

Coliban River at Malmsbury Common, by Imagine Photography

Table 5.6.5 Potential environmental watering for the Coliban system under a range of planning scenarios

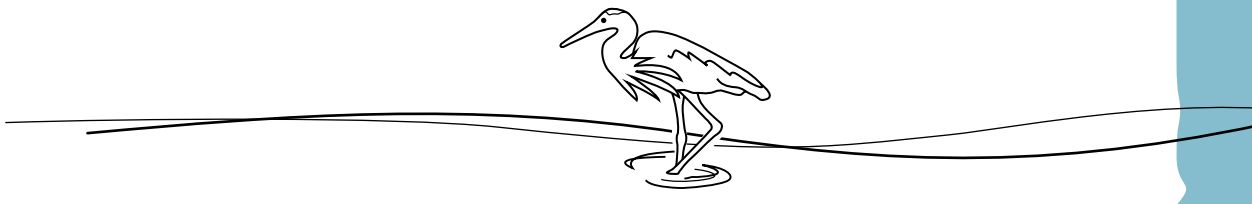
Planning scenario	Drought to dry	Average to wet
Expected river conditions	• Little or no unregulated flows	• Some unregulated river flows from tributary inflows
Expected availability of water for the environment	• Minimal passing flows and low volume to withhold for use at other times in the season	• Moderate-to-high passing flows with good volumes available 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 1 (high priorities)	• Pulsed summer/autumn low flows • Summer/autumn low flows	• Summer/autumn low flows • Summer/autumn freshes
Potential environmental watering – tier 2 (additional priorities) [1,2]	• Increased magnitude of summer/ autumn low flows	• N/A
Possible volume of water for the environment required to achieve objectives	• 900 ML (tier 1) • 250 ML (tier 2)[2]	• 1,200 ML (tier 1)
Priority carryover requirements	• Reserve passing flows for 2019–20	

[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.*

Risk management

Environmental watering program partners have considered and assessed risks and identified mitigating strategies relating to environmental flows in 2018–19. Risks and mitigating actions are continually reassessed by program partners throughout the water year (see section 1.3.6).



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

The Loddon system contains five waterways that can receive regulated environmental flows: the Loddon River, Serpentine Creek, Tullaroop Creek, Birchs Creek and Pyramid Creek.

Engagement

Table 5.7.1 shows the partners and stakeholder organisations with which North Central CMA engaged when preparing their seasonal watering proposals.

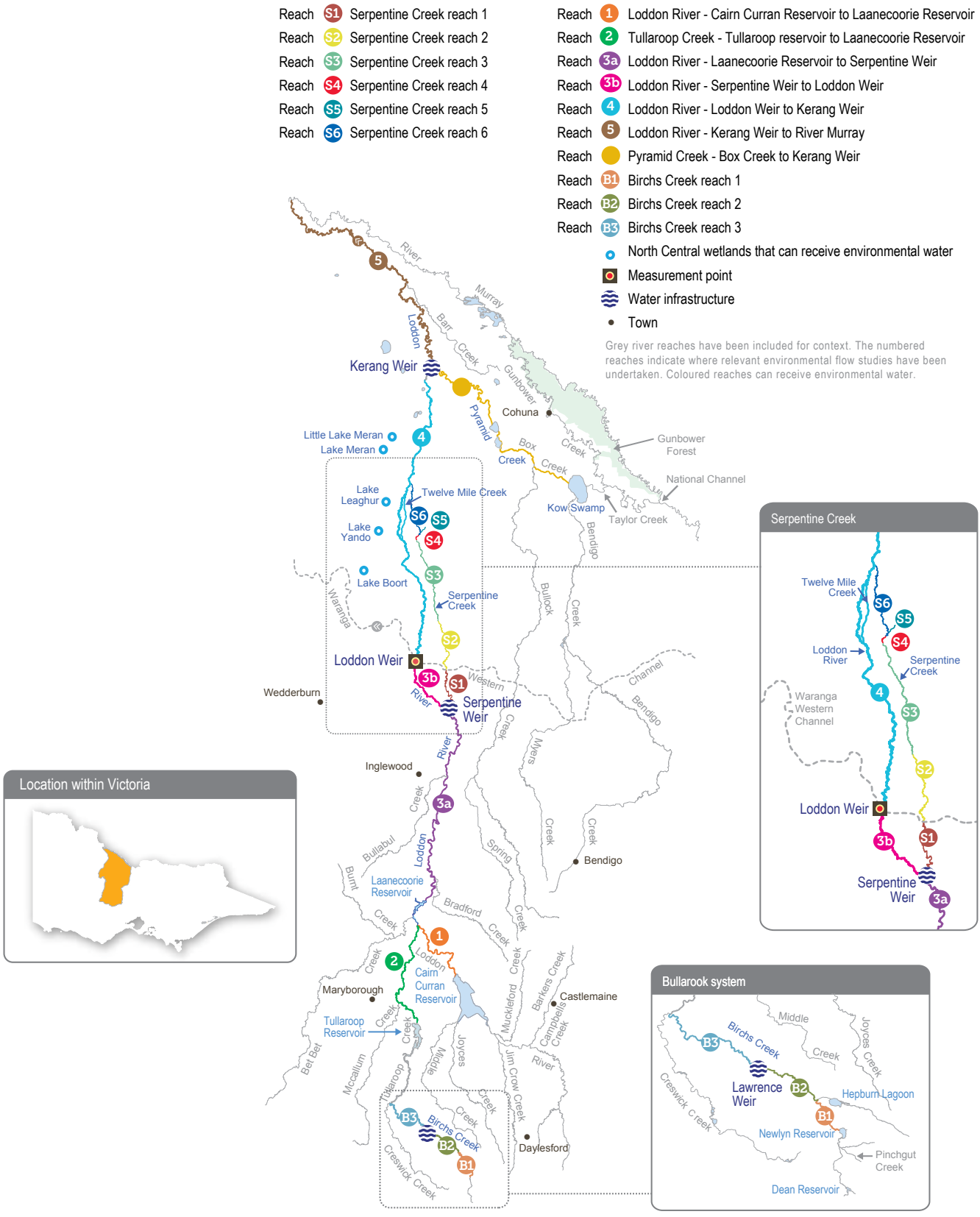
Seasonal watering proposals are informed by longer-term regional catchment strategies, regional waterway strategies, environmental flow studies, water management plans and other studies. These incorporate a range of environmental, cultural, social and economic perspectives and longer-term integrated catchment and waterway management objectives. For further details, refer to the *North Central Regional Catchment Strategy* and *North Central Waterway Strategy*.

Table 5.7.1 Partners and stakeholders engaged in developing the Loddon system seasonal watering proposal

Partner and stakeholder engagement
• Barapa Barapa Nations Traditional Owners
• Birchs Creek Environmental Water Advisory Group, Loddon Murray Wetlands Environmental Water Advisory Group and Loddon River Environmental Water Advisory Group (comprising community members and representatives of Field & Game Australia, Birdlife Australia, Game Management Authority, NCCMA's Community Consultative Committee, Gannawarra Shire Council, Swan Hill Rural City Council, Loddon Shire Council, Campaspe Shire Council, Parks Victoria, Goulburn-Murray Water, Central Highlands Water, the Victorian Environmental Water Holder)
• Commonwealth Environmental Water Office and the Victorian Environmental Water Holder
• Commonwealth Environmental Water Office
• Dja Dja Wurrung Clans Aboriginal Corporation
• Field & Game Australia
• Game Management Authority
• Goulburn-Murray Water
• Loddon Shire Council, Campaspe Shire Council
• Parks Victoria
• Victorian Environmental Water Holder
• VRFish
• Wamba Wemba Traditional Owners
• Yorta Yorta Nation Aboriginal Corporation

Sunset by the Loddon River at Kerang, by Zarleen Blakeley

Figure 5.7.1


Reach S1 Serpentine Creek reach 1
Reach S2 Serpentine Creek reach 2
Reach S3 Serpentine Creek reach 3
Reach S4 Serpentine Creek reach 4
Reach S5 Serpentine Creek reach 5
Reach S6 Serpentine Creek reach 6
Reach 1 Loddon River - Cairn Curran Reservoir to Laanecoorie Reservoir
Reach 2 Tullaroop Creek - Tullaroop reservoir to Laanecoorie Reservoir
Reach 3a Loddon River - Laanecoorie Reservoir to Serpentine Weir
Reach 3b Loddon River - Serpentine Weir to Loddon Weir
Reach 4 Loddon River - Loddon Weir to Kerang Weir
Reach 5 Loddon River - Kerang Weir to River Murray
Reach Pyramid Creek - Box Creek to Kerang Weir
Reach B1 Birchs Creek reach 1
Reach B2 Birchs Creek reach 2
Reach B3 Birchs Creek reach 3
North Central wetlands that can receive environmental water
Measurement point
Water infrastructure
Town
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.
Location within Victoria
Serpentine Creek
Bullarook system
Kerang Weir
Cohuna
Gunbower Forest
National Channel
Kow Swamp
Taylor Creek
Little Lake Meran
Lake Meran
Lake Leaghur
Lake Yando
Lake Boort
Twelve Mile Creek
Serpentine Creek
Loddon Weir
Serpentine Weir
Wedderburn
Inglewood
Bendigo
Laanecoorie Reservoir
Cairn Curran Reservoir
Tullaroop Reservoir
Maryborough
Castlemaine
Daylesford
Birchs Creek
Lawrence Weir
Hepburn Lagoon
Newlyn Reservoir
Pinchgut Creek
Dean Reservoir
Loddon River
Waranga Western Channel

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

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.

The Loddon River continues to be an important place for Traditional Owners and their Nations. The Registered Aboriginal Party (RAP) in the region is the Dja Dja Wurrung Clans Aboriginal Corporation. Representatives from Dja Dja Wurrung, Barapa Barapa and Wamba Wemba Traditional Owners were engaged during the preparation of the Loddon system seasonal watering proposals.

Environmental values

The Loddon River system supports platypus, frogs, turtles and 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 sections of the Loddon River. Pyramid Creek supports large-bodied fish (such as golden perch, Murray cod and silver perch) and is an important corridor for fish migration between the Loddon and Murray systems. Engineering works to provide fish passage at the Chute, Box Creek regulator and Kerang Weir in recent years have been important in reopening these migration routes.

Social economic values

The Loddon River supplies the Loddon Valley Irrigation Area and is essential for the area's prosperity. In the highly productive irrigation areas in the lower catchment, the main land uses are dairying, pasture and irrigated horticulture. Mixed farming and cereal growing dominate the middle and upper catchment.

Storages and weir pools that form part of the irrigation network are used for recreational activities, particularly during the drier months when river levels are low. The river is an important recreational hub with locals and visitors using it for camping, hunting, waterskiing, canoeing, boating, and for walking and cycling along its banks. Murray cod and golden perch are stocked in the Loddon River and are important recreational fishing species. Bridgewater on Loddon hosts regional and national waterskiing and triathlon competitions.

Environmental watering objectives in the Loddon River system

	Maintain river red gum, tea tree and lignum and provide opportunities for new plants to germinate and grow Limit encroachment of emergent macrophytes and allow in-stream vegetation to spread to channel margins Establish and maintain a variety of vegetation types
	Protect and increase populations of native fish by providing flows for them to move upstream and downstream Maintain the water quality and the variety of aquatic habitats
	Maintain or increase the habitat available to turtles
	Create opportunities for platypus to disperse throughout the system Maintain access to foraging habitat Provide opportunities for successful breeding and recruitment
	Maintain the water quality in river pools

System overview

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 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.

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 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.

Recent conditions

Rainfall patterns in the Loddon catchment varied throughout 2017–18. There was a relatively dry period in September/October 2017 and a short-lived wet period in November 2017 to January 2018. However, the late spring/early summer rain did not deliver high inflows because the rainfall was sporadic and the catchment was fairly dry. Late summer and autumn were particularly dry and environmental flows were required to maintain flows in the reaches downstream of Loddon Weir.

Most flow recommendations for summer low flows and freshes in the reaches upstream of Loddon Weir were exceeded because large volumes of irrigation water were delivered. In the priority reach, between Loddon Weir and Kerang Weir, all environmental flow components were delivered except for those which rely on unregulated flows or storages spilling.

In 2017, winter low flows and a spring fresh were delivered to Serpentine Creek for the first time. The releases helped managers understand the rate at which managed flows move through Serpentine Creek and into Pennyroyal and Bannacher creeks at the end of the system. The observations will help environmental planning in future years to support objectives for waterbirds, vegetation and native fish while limiting impacts on landholders.

Pyramid Creek and the Loddon River have benefited from actions implemented in the first three years of the North Central CMA's *Native Fish Recovery Plan – Gunbower and Lower Loddon*. Reinstatement of habitat, fish passage and an improved flow regime have significantly improved conditions for fish, particularly Murray cod and golden perch. Two environmental flows were provided to Pyramid Creek during 2017–18 to support the plan. 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 was delivered at the end of the irrigation season in mid-May to control the rate of drawdown in Pyramid Creek, to prevent fish becoming stranded when the irrigation system is drained. The 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 5.7.2 shows potential environmental watering actions and their environmental objectives.

Table 5.7.2 Potential environmental watering actions and objectives for the Loddon River system

Potential environmental watering	Environmental objectives
Loddon River (reach 1)	
Summer/autumn freshes (up to 4 freshes of 35–80 ML/day for 1–3 days in December–May)	• Provide a cue for fish movement so they access alternate habitats • Wash organic matter into the stream to drive the aquatic food webs • Mix and re-oxygenate pools and dilute concentrated salt • Inundate lower banks to wet the soil and promote the establishment, growth and survival of sedges and reeds
Winter/spring freshes (1–2 freshes of 400–700 ML/day for 1–5 days in July–October)	• Promote recruitment of riparian vegetation • Maintain connectivity between pools for native fish movement • Flush accumulated leaf litter from banks and low benches into the channel to drive aquatic food webs
Tullaroop Creek (reach 2)	
Summer/autumn freshes (up to 3 freshes of 30–40 ML/day for 1–3 days in December–May)	• Provide cues and passage for native fish dispersal through the system • Wash organic matter into the stream to drive aquatic food webs • Maintain water quality in pools • Inundate lower banks to wet the soil and promote the establishment, growth and survival of sedges and reeds
Winter/spring freshes (1 fresh of 200–400 ML/day for 1–5 days in July–October)	• Maintain connectivity between pools for native fish movement • Stimulate movement of Murray cod to breeding grounds • Promote the recruitment of riparian vegetation on banks and benches • Flush accumulated leaf litter from banks and low benches into the channel to drive aquatic food webs and increase ecological productivity

Table 5.7.2 Potential environmental watering actions and objectives for the Loddon River system *continued*

Potential environmental watering	Environmental objectives
Loddon River (reach 4)	
Summer/autumn freshes (up to three freshes 50–100 ML/day for 3–4 days in December–May)	• Maintain pool habitat and reduce the likelihood of low-dissolved-oxygen water
Winter/spring high flow (1 high flow of 450–750 ML/day for 6–10 days in June–November)[1]	• Provide cues for native fish movement • Flush organic matter from in-channel benches to aid carbon and nutrient cycles • Flush fine sediment and scour biofilms to replenish food supply
Summer/autumn low flows (25–50 ML/day December–May)	• Maintain connectivity between pool habitats for native fish
Winter/spring low flow (50–100 ML/day June–November)	• Maintain connectivity between pool habitats during winter to facilitate movement of native fish • Maintain water quality in pools • Maintain bank and fringing vegetation
Autumn high flow (1 high flow of 400 ML/day for 6–10 days in March–May)	• Facilitate the movement and dispersal of juvenile fish and platypus
Serpentine Creek (reach 1)[2]	
Winter/spring fresh (1 fresh of 40–150 ML/day for 2 days in June–November)	• Maintain habitat for native fish and waterbugs • Flush accumulated organic matter from benches to promote carbon cycling and prevent risk of low-dissolved-oxygen conditions during summer months
Summer/autumn freshes (up to 3 freshes of 30–40 ML/day for 1–2 days in December–May)	• Wet in-stream benches • Flush fine sediment and scour biofilms to replenish food supply • Flush organic matter from in-channel benches to aid carbon and nutrient cycles • Provide flow variability to maintain species diversity of fringing vegetation
Summer/autumn low flows (10–20 ML/day in December–May)	• Maintain connectivity between pools to connect fish habitats • Maintain water quality and prevent low-dissolved-oxygen conditions • Maintain foraging habitat for platypus • Enable the growth of in-stream aquatic vegetation
Winter/spring low flows (20–30 ML/day in June–November)	• Maintain spawning habitat and water levels for river blackfish • Maintain the vegetation fringing the bank • Inundate snags to maintain biofilms and foodweb productivity
Pyramid Creek and Loddon River (reach 5)	
Autumn/winter low flow (90–200 ML/day May–August)	• Maintain connectivity between habitats and improve water quality • Maintain the fringing vegetation on the lower banks of the channel • Provide sufficient water depth to inundate snags and maintain biofilms
Spring high flow (1 high flow of 700–900 ML/day for 10 days in September-November)	• Maintain connectivity between habitats and improve water quality • Trigger and facilitate fish movement and breeding, particularly golden perch and silver perch, to increase local populations
Autumn high flow (1 high flow of 700–900 ML/day for 10 days in March-May)	• Maintain connectivity between habitats and improve water quality • Trigger and facilitate the movement of juvenile fish • Provide recruitment opportunities for Murray cod and other native fish species

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

[2] *Flows in Serpentine Creek will be allowed to continue down Pennyroyal Creek, Bannacher Creek and Nine Mile Creek with the agreement of landholders.*

Scenario planning

Table 5.7.3 outlines the potential environmental watering and expected water use under a range of planning scenarios.

Due to high regulation in the Loddon River system, the highest-priority reach between Loddon Weir and Kerang Weir relies almost entirely on environmental flows to provide its water regime; the exception is flow provided by floods and unregulated spills from storages. There are also many system constraints that limit the ability to deliver flows when lots of water is available. Due to these reasons, the planned environmental flows change little between scenarios.

Under drought to dry scenarios, low flows in the Loddon River will be released at variable rates to provide refuge for fish to survive. Small freshes in summer are essential under this scenario to maintain adequate concentrations of dissolved oxygen for fish and other aquatic animals during heatwaves.

One to three summer/autumn freshes and one high flow in spring are planned under all scenarios. A spring high flow — combining flows from the Loddon River and Pyramid Creek through Kerang Weir — is a high priority for fish migration. The release of an autumn high flow depends on increased water availability in the Loddon system under average and wet scenarios. Flows of up to 200 ML per day will be maintained in Pyramid Creek year-round (that is, including outside the irrigation season) to protect habitat for resident Murray cod.

While there is expected to be enough water available to meet the priority objectives 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 maximise 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.

Pyramid Creek, by North Central CMA

Table 5.7.3 Potential environmental watering for the Loddon River system under a range of planning scenarios

Planning scenario	Drought	Dry	Average	Wet
Expected river conditions	• Negligible contributions from unregulated reaches and tributaries of the Loddon River, consumptive water deliveries during the irrigation season	• Small contributions from unregulated reaches and tributaries of the Loddon River contributing to low flows, consumptive water deliveries during the irrigation season	• Unregulated flows will provide low flows and multiple freshes, most likely in winter and spring • Consumptive water deliveries during the irrigation season	• Spills from Loddon system storages will provide extended-duration high flows and overbank flows most likely in late winter to spring
Expected availability of water for the environment[1]	• Up to 21,000 ML	• Up to 24,000 ML	• Up to 25,500 ML	• Up to 26,000 ML
Loddon River (reach 1) and Tullaroop Creek (reach 2)				
Potential environmental watering	• 3 summer/autumn freshes • 1 winter fresh • Winter/spring low flows			
Loddon River (reach 4)				
Potential environmental watering – tier 1 (high priorities)	• 1–3 summer/autumn freshes • 1 winter/spring high flow • Winter/spring low flows • Summer/autumn low flows		• 3 summer/autumn freshes • 1 winter/spring high flow • Winter/spring low flows • Summer/autumn low flows • 1 autumn high flow	
Potential environmental watering – tier 2 (additional priorities)	• Increased magnitude of winter/spring and summer/autumn low flows	• Increased magnitude of summer/autumn low flows		
Serpentine Creek (reach 1)				
Potential environmental watering – tier 1 (high priorities)	• 1–3 summer/autumn freshes • 1 winter/spring fresh • Summer/autumn low flows • Winter/spring low flows			
Potential environmental watering – tier 2 (additional priorities)	• Increased magnitude of winter/spring and summer/autumn low flows			
Loddon River, Tullaroop Creek and Serpentine Creek				
Possible volume of water for the environment required to achieve objectives	• 9,000 ML (tier 1) • 6,800 ML (tier 2)[3]	• 12,400 ML (tier 1) • 3,700 ML (tier 2)[3]	• 8,300–14,400 ML	
Pyramid Creek and Loddon River (reach 5)				
Potential environmental watering – tier 1 (high priorities)	• 1 spring high flow • Autumn/winter low flows			
Potential environmental watering – tier 2 (additional priorities)	• 1 autumn high flow			
Possible volume of water for the environment required to achieve objectives	• 5,000 ML (tier 1)[2] • 6,000 ML (tier 2)[2,3]			

[1] *Does not include water available in the Goulburn and Murray systems that could be made available to support the achievement of environmental objectives in the Loddon system, subject to trading rules.*

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

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

Risk management

Environmental watering program partners have considered and assessed risks and identified mitigating strategies relating to environmental flows in 2018–19. Risks and mitigating actions are continually reassessed by program partners throughout the water year (see section 1.3.6).

5.7.2 Boort wetlands

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 environmental.

The Boort wetlands are an important place for Traditional Owners and their Nations. The Registered Aboriginal Party (RAP) in the region is the Dja Dja Wurrung Clans Aboriginal Corporation. Representatives from the RAP and from Barapa Barapa and Wamba Wemba Traditional Owners were engaged during the preparation of the Boort wetlands seasonal watering proposal.

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.

Social and recreational values

The Boort wetlands provide many recreation opportunities. Lake Meran and Lake Boort are state game reserves and hunting is also allowed at Lake Yando and Lake Leaghur. The large expanse of open water at Lake Meran attracts visitors during holiday seasons and on weekends for boating, fishing and waterskiing. Lakes Yando, Boort and Leaghur contain excellent environmental values and birdwatchers and field naturalists regularly visit the lakes whether they are wet or dry.

Environmental watering objectives in the Boort wetlands

Maintain or increase the growth of river red gums and aquatic and amphibious vegetation

Rehabilitate habitat and provide breeding opportunities to maintain local and regional populations of birds, fish, frogs and turtles

System overview

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. Based on seasonal outlooks at the start of the water year, there is expected to be enough water available to meet objectives under all climate scenarios in 2018–19, but the ability to deliver enough water for the environment to lakes 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.

Recent conditions

Rainfall throughout the Loddon catchment and the Boort wetlands varied throughout 2017–18. Winter 2017 had near-average rainfall; September and October 2017 were dry; December 2017 and early January 2018 had some high rainfall; and the rest of summer and autumn were very dry. The high rainfall at the end of spring and early summer did not deliver any inflows to the Boort wetlands, and the very hot and dry conditions later in the year accelerated drying in wetlands that held water from previous years.

Lakes Boort, Leaghur and Yando and Meran were all naturally flooded in spring 2016 and water levels are now receding, allowing wetland plants an opportunity to establish. Little Lake Meran was the only lake in the Boort wetlands system to which water for the environment was delivered in 2017–18. Little Lake Meran is normally disconnected from the Loddon floodplain, except for 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 is planned for winter/spring 2018, to maintain the growth of the saplings.

Scope of environmental watering

Table 5.7.4 shows potential environmental watering actions and their environmental objectives.

Table 5.7.4 Potential environmental watering actions and objectives for the Boort wetlands

Potential environmental watering	Environmental objectives
Wetland watering	
Little Lake Meran (partial fill in spring)	• Increase the growth and recruitment of river red gums • Provide feeding and breeding opportunities for waterbirds • Provide open-water and mudflat habitats to support aquatic food webs and provide habitat for waterbirds • Maintain the diversity of aquatic plant communities
Wetland drying	
Lake Boort, Lake Leaghur, Lake Meran and Lake Yando (promote natural drawdown and drying)	• These wetlands will be in a drying phase in 2018–19 • The drying will help maintain a high diversity of habitats across the landscape that can support a wide range of wetland-dependent birds and animals • Gradual drawdown at each wetland will help rehabilitate vegetation zones in and around the wetland

Scenario planning

Table 5.7.5 outlines the potential environmental watering and expected water use under a range of planning scenarios.

Little Lake Meran is the only wetland scheduled to receive water for the environment in 2018–19. River red gums that recruited in Little Lake Meran in 2011 are now mature enough to withstand a long period of inundation. The lake was partially filled in May 2018 after being dry for more than two years, and a top-up in spring 2018 will support the increased growth of river red gums on the lake. Water is planned to be provided under all climate scenarios.

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

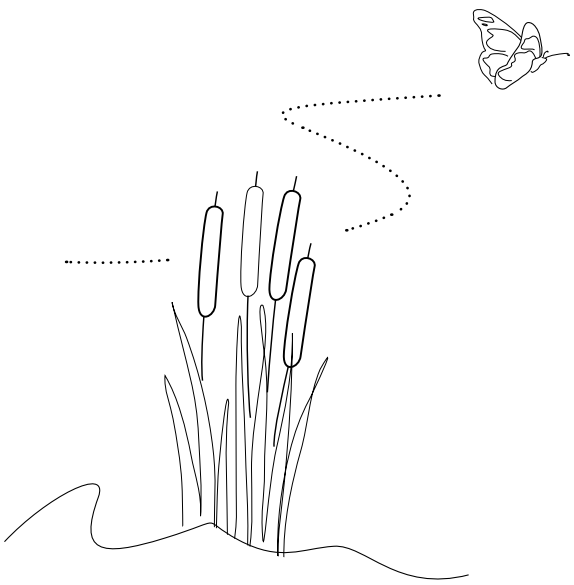
Under a wet scenario if large floods occur, most wetlands will fill from overbank flows from the Loddon River.

Table 5.7.5 Potential environmental watering for the Boort wetlands under a range of planning scenarios

Planning scenario	Dry	Average	Wet
Expected catchment conditions	• No natural inflows to wetlands	• Periods of high flows combined with localised catchment contributions expected to provide minor inflows to wetlands	• Multiple spills from Loddon system storages will provide extended durations of high flows and overbank flows which fill most wetlands
Potential environmental watering	• Little Lake Meran		
Possible volume of water for the environment required to achieve objectives	• 1,300 ML		

Risk management

Environmental watering program partners have considered and assessed risks and identified mitigating strategies relating to environmental flows in 2018–19. Risks and mitigating actions are continually reassessed by program partners throughout the water year (see section 1.3.6).



5.7.3 Birchs Creek

Birchs 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.

Birchs Creek is an important place for Traditional Owners and their Nations. The Registered Aboriginal Party (RAP) in the region is the Dja Dja Wurrung Clans Aboriginal Corporation. Representatives from the RAP were engaged during the preparation of the Birchs Creek seasonal watering proposal.

Environmental values

Birchs 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 has shown that platypus are present throughout the entire creek.

The recent removal of willows along the creek is expected to lead to improvements in water quality, habitat and riparian vegetation and in-stream vegetation. This in turn will have a positive effect on macroinvertebrate and small-bodied fish populations.

Social and economic values

Birchs Creek is highly valued by nearby communities for its aesthetic appeal and the value of having water in the landscape. The creek is used for recreational fishing and passive activities (such as walking and picnicking). Water from Birchs Creek (via Newlyn Reservoir) supplies irrigated agriculture, particularly potatoes.

Environmental watering objectives in Birchs Creek

	Increase the abundance of river blackfish, mountain galaxias and other native fish and provide opportunities for movement between pool habitats
	Maintain breeding populations of platypus and provide opportunities for surplus juveniles to disperse to Creswick Creek and Tullaroop Creek
	Enhance in-stream, fringing and riparian native plant communities

System overview

Birchs 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.

Birchs Creek receives tributary inflows from Rocky Lead, Langdons, Lawrence and Tourello creeks. In the downstream reaches, Birchs 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.

Recent conditions

The Birchs Creek catchment had near-average rainfall through late winter and early spring 2017, which caused Newlyn Reservoir to fill and spill in September and October 2017. The spills delivered a peak flow of 200 ML per day at the Smeaton gauge. Summer and autumn were warmer and drier than average, and flows in Birchs Creek throughout these seasons were low.

Reservoir spills, tributary inputs and groundwater discharge contributed to meeting environmental flow objectives in Birchs Creek throughout the year, and no environmental flows were delivered in 2017–18.

Scope of environmental watering

Table 5.7.6 shows potential environmental watering actions and their environmental objectives.

Table 5.7.6 Potential environmental watering actions and objectives for Birchs Creek

Potential environmental watering	Environmental objectives
Winter/spring fresh (1 fresh of 30 ML/day for 3 days in September–November)	• Maintain and improve streamside vegetation • Scour organic matter that has accumulated in the channel • Provide habitat and refuge for small fish • Maintain connectivity between pools for fish and platypus movement
Summer/autumn freshes (up to 3 freshes of 10 ML/day for 3 days in December–May)	• Maintain water quality to minimise risks to aquatic animals associated with low dissolved oxygen and high water temperature • Maintain connectivity between refuge pools for fish movement • Maintain and improve in-stream aquatic vegetation • Maintain macroinvertebrate population

Scenario planning

In a drought scenario, seasonal determinations in the Bullarook system (which supports allocations for Birchs Creek) will be less than 20 percent on 1 December 2018. Under this scenario, the VEWH will not receive an allocation on 1 December 2018. The water that was allocated to the VEWH the previous year, on 1 December 2017, will be retained until 30 November 2018 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 the summer. However, entitlement rules do not permit the retention of the carryover for higher-priority flows in summer and autumn. If the VEWH does not receive an allocation on 1 December 2018, water resources in the Bullarook system will be shared, to maintain critical human and environmental needs.

Under a dry scenario, there is a fair chance that the VEWH will receive its allocation of 100 ML on 1 December 2018, but an allocation is not assured and winter/spring inflows will be required to boost seasonal determinations up to the 20 percent trigger. If water is allocated under this scenario, delivery of summer/autumn freshes in 2019 will be a high priority, to mitigate the impacts of low flows in Birchs Creek.

Under an average-to-wet scenario, high rainfall will provide high flows to Birchs Creek and recharge groundwater aquifers. Water allocated to the VEWH on 1 December 2018 may be used to provide a summer/autumn fresh in March–April 2019. However, it is more likely that there will be sufficient flows in Birchs Creek provided by groundwater discharge, and the unused water for the environment will be carried over into the following year.

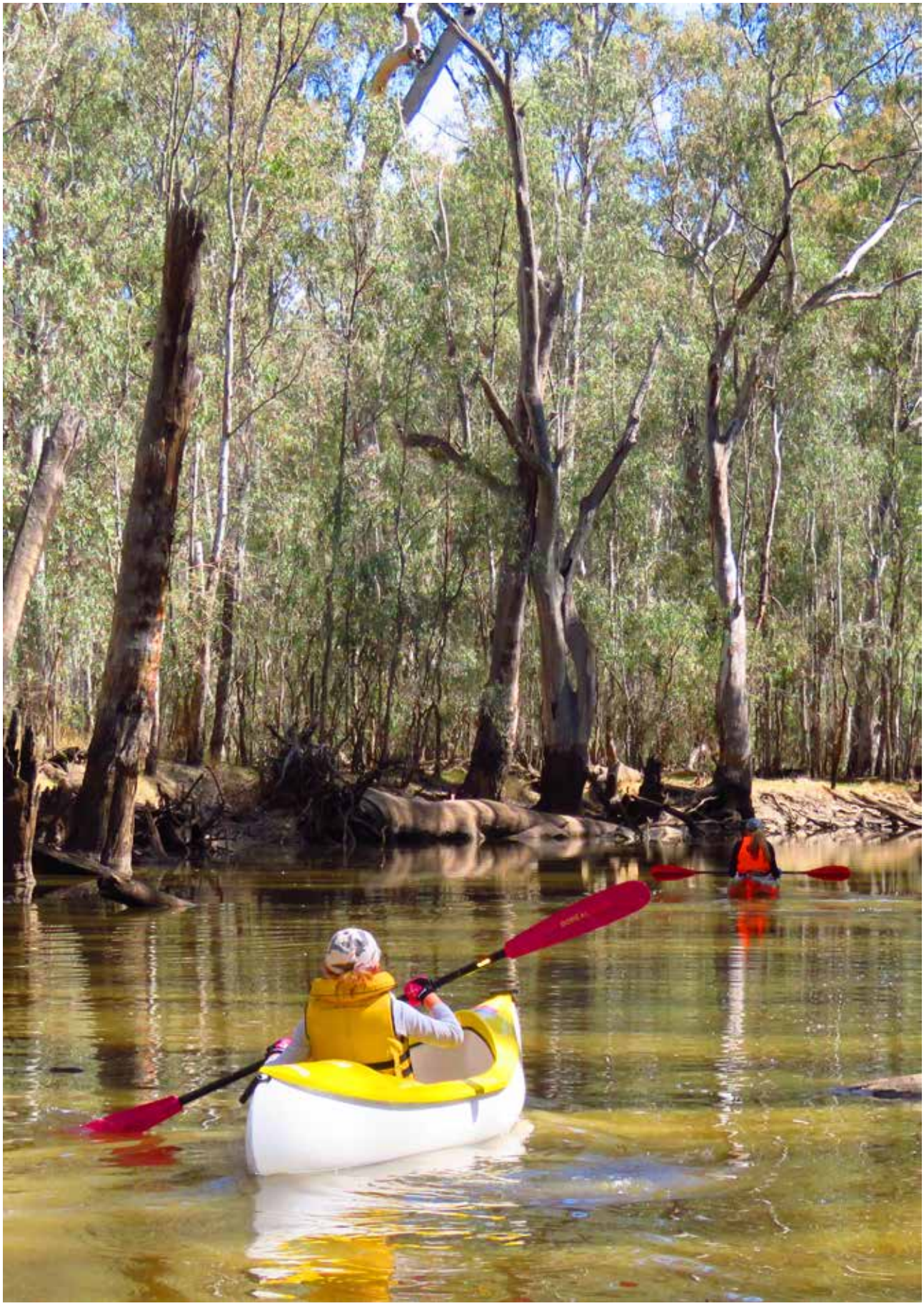
Birchs Creek at Nelson's Bridge, by North Central CMA

Table 5.7.7 Potential environmental watering for Birchs Creek under a range of planning scenarios

Planning scenario	Drought	Dry	Average to wet
Expected creek conditions	• Reservoir spill unlikely • Flows extremely low during winter/spring • Limited irrigation releases due to low allocations	• Reservoir spill possible • Low flows during winter/spring if no spills occur • Moderate irrigation releases	• Reservoir spills certain in winter/spring • Some unregulated flows through summer/autumn
Potential environmental watering	• 1 winter/spring fresh	• 1 winter/spring fresh • 1–3 summer/autumn freshes	• 1–3 summer/autumn freshes
Possible volume of water for the environment required to achieve objectives	• 100 ML	• 100–200 ML	• 100 ML

Risk management

Environmental watering program partners have considered and assessed risks and identified mitigating strategies relating to environmental flows in 2018–19. Risks and mitigating actions are continually reassessed by program partners throughout the water year (see section 1.3.6).



Paddling at Gunbower Creek, by Sydney Harbour Kayaks