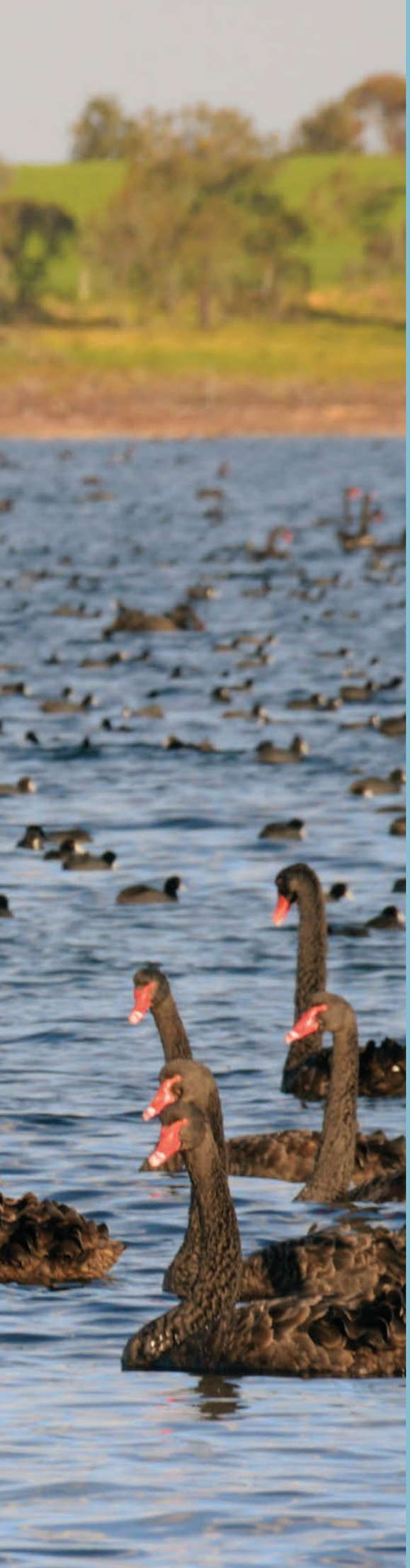
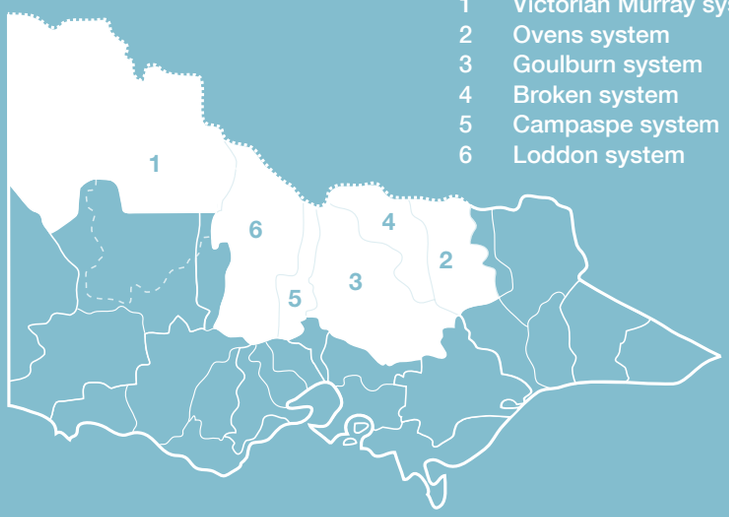


Section 5

Northern Region



1 Victorian Murray system
2 Ovens system
3 Goulburn system
4 Broken system
5 Campaspe system
6 Loddon system

5.1 Northern Region overview

The northern region has a vital network of rivers, wetlands and floodplains that provide homes for ancient river red gums and a diversity of other plants and animals. Priority sites include the Goulburn, Broken, Loddon and Campaspe rivers as well as wetlands and floodplains on these systems and on the Victorian Murray system, including Barmah Forest, Gunbower Forest, Hattah Lakes and Lindsay, Wallpolla and Mulcra islands.

Local Indigenous communities have an enduring connection to these sites, many of which have important heritage values (such as scar trees, middens, burial sites, artefacts and ovens). Waterways across the northern region provide highly-valued amenity and recreational opportunities for residents and visitors, as well as business opportunities from tourism. Importantly, these waterways also support irrigated agriculture, which contributes significantly to Australia's prosperity through food and fibre production.

Environmental water available for use in the northern Victorian systems is held in the Ovens, Murray, Goulburn, Broken, Loddon and Campaspe storages, which also hold water for consumptive water entitlements. The water systems of the northern region are highly connected. Infrastructure and water trading allows water to move from one system to another. This allows environmental water to move between systems for delivery to priority environmental sites across northern Victoria, if needed. However most environmental water in these systems is prioritised to provide benefits in the regions in which the water is held.

Seasonal outlook 2015–16

Each year on 15 May, the Northern Victorian 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 2015–16 outlook suggests water availability will potentially be lower than in recent years, with allocations against high-reliability entitlements likely to be slower to reach 100 per cent. Under a dry inflow scenario (for example, assuming inflows remain similar to the lowest 10 per cent of inflows on record), only the Goulburn and Loddon systems are expected to reach 100 per cent allocations against high-reliability entitlements for the year. If inflows are worse than this, allocations could be lower.

Environmental demands in northern Victoria are generally highest in winter and spring. As the outlook indicates, water availability early in the season may be relatively low, so carryover from 2014–15 will be important to help meet early season demands. If conditions remain very dry across the northern region, environmental watering will likely focus on delivery of actions planned under a dry scenario. Carryover planning for 2016–17 will also be essential under continuing dry conditions.

The Victorian Environmental Water Holder (VEWH) coordinates with other environmental water holders in northern Victoria, New South Wales and South Australia to deliver environmental outcomes at the broader Murray-Darling Basin scale.

The VEWH liaises with the Murray-Darling Basin Authority and the Commonwealth Environmental Water Office to maximise the benefits of environmental water delivery in Victorian systems. Delivery of Living Murray and Commonwealth environmental water to meet Victorian environmental water objectives is covered in the following sections.

Environmental water delivered through northern Victorian waterways can sometimes be reused to achieve further environmental benefits downstream (see section 1.3.3 on return flows). If return flows are not to be reused at Victorian environmental sites, VEWH, Living Murray and Commonwealth Environmental Water Holder (CEWH) return flows will continue to flow across the border to South Australia where they will be used to provide environmental benefits at sites such as those in the Coorong, Lower Lakes and Murray Mouth region.

The VEWH may also authorise waterway managers to order Living Murray and Commonwealth water for downstream sites, provided there are no adverse impacts on Victorian waterways.

What is the Murray-Darling Basin Plan?

Northern Victoria is a part of the Murray-Darling Basin and environmental water deliveries in this region are subject to the requirements of the Murray-Darling Basin Plan. The Basin Plan was developed by the Murray-Darling Basin Authority under the *Commonwealth Water Act 2007* and became law in November 2012. The Basin Plan sets legal limits on the amount of water that can be taken from the Murray-Darling Basin's surface and groundwater resources. Chapter 8 of the Basin Plan also sets out a high-level environmental watering plan which defines environmental objectives to protect, restore and build the resilience of water-dependent ecosystems and their associated functions. The Victorian Environmental Water Holder's environmental planning and delivery is consistent with the requirements of the Basin Plan. The potential environmental watering outlined in sections 4.3, 4.4 and 5 fulfil Victoria's obligations to identify annual environmental watering priorities for Victoria's water resource areas under section 8.26 of the Basin Plan.

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

**Lower Murray Water are a delivery partner for the lower Murray wetlands*

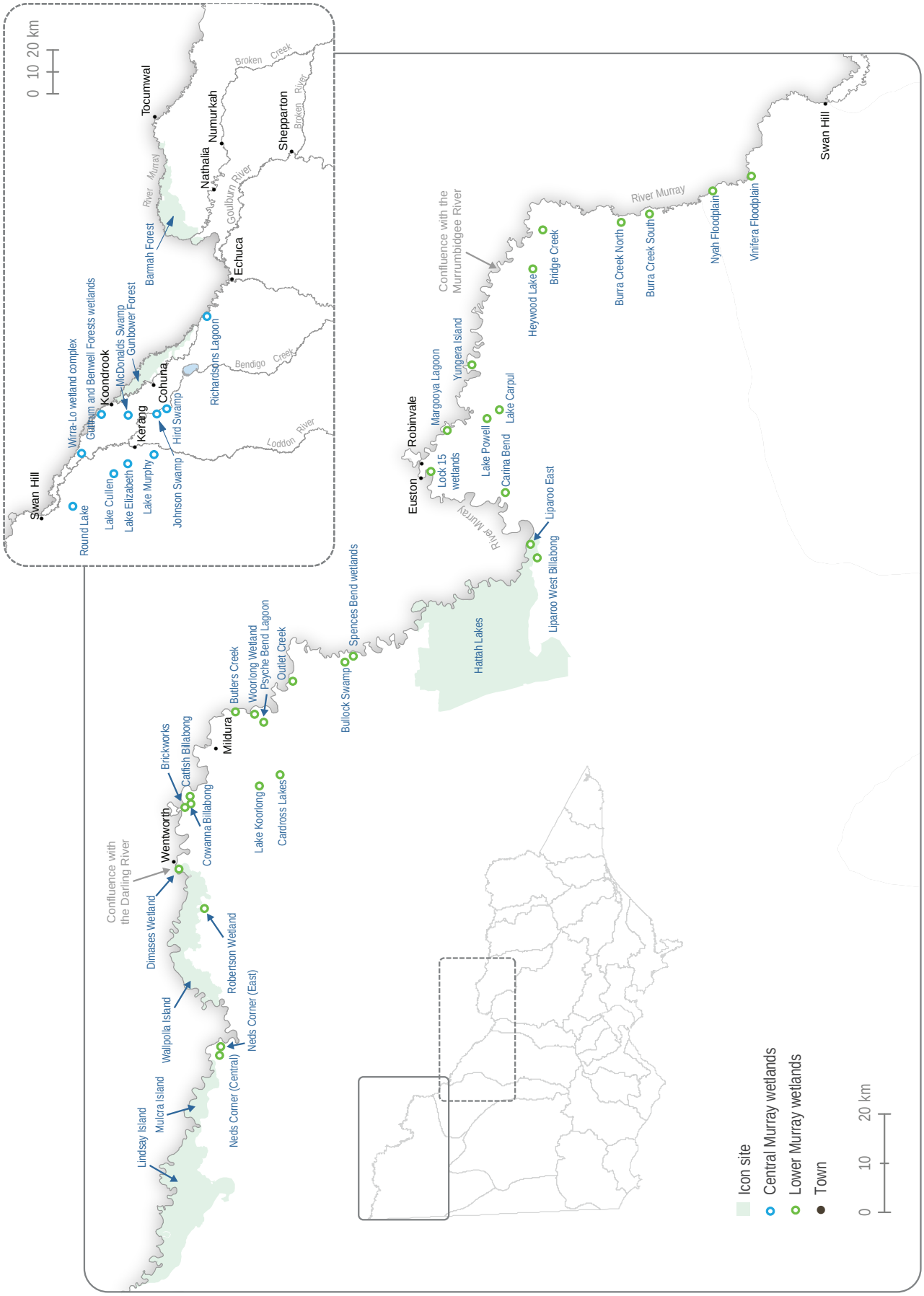
Region overview

The Victorian Murray system contains a myriad of significant floodplains and wetland systems covering the Goulburn Broken, North Central and Mallee catchment management authority (CMA) regions (see Figure 5.2.1). The system contains floodplains and wetlands that are of international importance and include the iconic Hattah Lakes, Barmah Forest and Kerang wetlands, as well as several nationally and regionally significant sites. The system provides a wide range of habitat types that support rare and threatened waterbird species including the painted snipe, brolga, royal spoonbill and white-bellied sea eagle. They are also home to the endangered Murray hardyhead fish. The Victorian Murray system supports a variety of recreational activities (such as camping, fishing, water sports, bird watching and recreational hunting) and Indigenous cultural heritage values (such as scar trees, middens, burial sites, artefacts and ovens).

Environmental water can be supplied from a range of sources to meet demands in the Victorian Murray system. This includes 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 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 environmental water availability.

Little Rushy Swamp, by Keith Ward

Figure 5.2.1 The Victorian Murray system



5.2.1 Barmah Forest

Environmental watering objectives in Barmah Forest
Enhance the health of river red gum communities and aquatic vegetation within the wetlands and watercourses and on the floodplain Encourage germination of Moira grass
Allow colonial waterbirds to successfully fledge their young
Use flows to connect floodplains to the river, boosting floodplain animal and bird habitats and providing bugs and other food resources for native fish species, waterbirds, frogs and turtles
Protect and boost populations of native fish (including the threatened southern pygmy perch) by providing flows to encourage fish to spawn

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 is a significant feeding and breeding site for waterbirds including egrets, spoonbills and night herons, as well as for significant fish, frog and turtle populations.

The forest also supports a broad range of floodplain vegetation communities including river red gum forest, river red gum woodland, wetlands and the threatened Moira grass plains.

Social and economic values

The Barmah Forest supports a variety of recreational and tourism activities (such as camping, bushwalking, fishing, water sports, river cruises and bird watching).

The forest is valued in recognition of its importance as part of Australia's heritage and natural values. Both Indigenous and European cultural heritage values are present. Indigenous sites of significance include scar trees, middens, burial sites, artefacts and ovens. Non-Indigenous artefacts are largely associated with previous forestry and grazing in the forest. The Barmah Forest continues to be a place of significance for Traditional Owners and their Nations in the region.

System overview

The Barmah–Millewa Forest covers 66,000 ha and straddles the Murray and Edwards rivers between the townships of Tocumwal, Deniliquin and Echuca. The Victorian component is the Barmah National Park and River Murray Regional Park covering 28,500 ha of forest and wetlands.

Water management in the Barmah–Millewa Forest depends on gravity distribution from the River Murray. When river flows are above 15,000 ML per day downstream of Yarrawonga Weir both sides of the forest are managed as a whole. When flows are below this each side of the forest can be managed separately by operating the regulators individually. Below flows of 10,300 ML per day downstream of Yarrawonga Weir all regulators usually remain closed.

River regulation and water extraction from the River Murray has reduced the frequency, duration and magnitude of flood events in the Barmah–Millewa Forest. This has affected the diversity, extent and condition of vegetation communities and the habitat and health of dependent animal species.

Environmental water releases seek to build on unregulated flows and the delivery of consumptive water en route to maximise environmental outcomes at Barmah Forest. As Barmah Forest is located in the upper reaches of the River Murray, environmental water delivered to the forest can often be used again at sites further downstream as part of multi-site watering events; this occurs through the use of return flows.

Recent conditions

No environmental water was released in Barmah–Millewa Forest in 2014–15. However, in July 2014, very high rainfall in the upper Murray system led to flooding in the Barmah–Millewa Forest. Unregulated conditions persisted until early-August, after which all Barmah–Millewa Forest regulators were closed. Despite wet conditions occurring over the subsequent months, river releases were kept mostly within the river channels, reducing forest inundation. Notable exceptions included three small rain-rejection events in November 2014, January 2015 and March 2015 which caused some low-level flooding in the forest. This natural peak flow event created sufficient flow variability in the River Murray channel to trigger golden perch spawning.

Australasian bittern, a nationally endangered bird species, was frequently heard and occasionally sighted at Boals Deadwoods, an important wetland in the Barmah Forest.

Some 500 Australian white ibis started nesting at Boals Deadwoods in Barmah Forest and Reed Beds Swamp in Millewa Forest but both nesting sites were prematurely abandoned. This coincided with a brief but rapid period of lower-than-normal flows, which may have been why the birds abandoned their nests.

Scope of environmental watering

Potential environmental watering actions and their environmental objectives are shown in Table 5.2.1.

Table 5.2.1 Potential environmental watering actions and objectives for Barmah Forest

Potential environmental watering	Environmental objectives
Spring/summer pulsed flows in the River Murray channel (3 pulses of up to 500 ML/day for 8 days each during October–December)	▸ Provide flow variability within the main river channel to encourage spawning of native fish species, primarily perch
Spring baseflow in Gulf, Smiths, Big Woodcutter and Boals creeklines (targeting about 500 ML/day for 2–3 months during September–November)	▸ Allow lateral connectivity for native fish species to provide access to a variety of floodplain habitats and food resources that allows them to complete their life cycles, focused on meeting the requirements of southern pygmy perch ▸ Provide connectivity and inundated habitats for other wetland-dependent fauna (such as waterbirds, frogs and turtles)
Winter/spring inundation of wetlands (variable flow rates to extend the duration and inundation extent of natural flooding during August–September)	▸ Enhance the health of aquatic vegetation within the wetlands, watercourses and fringing forest areas of the lower terraces of the Barmah Forest floodplain
Spring inundation of Moira grass plains (variable flow rates to extend the duration and inundation extent of natural flooding during October–November)	▸ Provide flooding of sufficient duration to encourage the establishment of new Moira grass germinants, building on the outcomes of the seed-bank created by the 2013–14 environmental watering
Spring/summer inundation to support bird breeding in Boals Deadwoods wetland (targeting flow of about 200 ML/day to maintain appropriate inundation extent for about 3 months during October–December)	▸ Maintain water levels to allow colonial waterbirds to successfully fledge their young should breeding occur in response to natural flooding
Spring/summer inundation of Barmah Forest floodplain (variable flow rates to extend the duration and inundation extent of natural flooding during October–November)	▸ Enhance the health of river red gum communities on the lower terraces of the Barmah Forest floodplain by extending the tail of naturally occurring floods

Scenario planning

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

Environmental water requirements vary significantly in Barmah Forest in response to natural conditions. Under drier conditions, objectives focus on improving river and creek conditions to sustain fish movement and recruitment.

As conditions become wetter, the focus shifts to the provision of larger-scale outcomes (such as extending the duration of natural flooding to promote the germination of Moira grass seedlings and providing benefits to broader floodplain vegetation communities including river red gum forests). Similarly, if natural flooding stimulates a colonial bird breeding event in Barmah Forest, environmental water will be delivered to support the colony through to fledging.

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 very unlikely ▸ Flows in the River Murray will remain within channel all year	▸ Low probability of small, unregulated flows in spring ▸ Small chance of overbank flows in spring	▸ Likely chance of unregulated flows in winter/spring ▸ Likely chance of overbank flows	▸ High probability of moderate-to-large unregulated flows during winter/spring ▸ Expected overbank flows
Potential environmental watering	▸ Spring/summer pulsed flows in the River Murray channel	▸ Spring baseflow in Gulf, Smiths, Big Woodcutter and Boals creeklines	▸ Winter/spring inundation of wetlands ▸ Spring inundation of Moira grass plains ▸ Spring/summer inundation to support bird breeding	▸ Spring/summer inundation of Barmah Forest floodplain
Possible volume of environmental water required to achieve objectives[1]	▸ 12,000 ML ▸ (with 12,000 ML return flow)	▸ 45,000 ML ▸ (with 30,000 ML return flow)	▸ 560,000 ML ▸ (with 369,000 ML return flow)[2]	▸ 300,000 ML ▸ (with 210,000 ML return flow)[2]

1 The possible volumes of environmental water required in Barmah Forest are estimates; the actual volumes required are highly dependent on natural conditions.
2 The volumes identified include the volume required to achieve Moira grass and floodplain objectives in both the Barmah and Millewa forests.

Risk management

In preparing its seasonal watering proposal, the Goulburn Broken CMA considered and assessed risks and identified mitigating strategies relating to the implementation of environmental watering. Risks and mitigating actions are continually reassessed by program partners throughout the water year (see section 1.4.4).

Engagement

The Goulburn Broken CMA consulted key stakeholders when preparing the seasonal watering proposal for Barmah Forest. Table 5.2.3 shows these stakeholders.

Seasonal watering proposals are informed by longer-term regional waterway strategies, environmental water management plans and environmental flow studies which incorporate environmental, cultural, social and economic considerations.

Table 5.2.3 Key stakeholders engaged in the development of the Barmah Forest seasonal watering proposal

Stakeholder engagement
▸ Department of Environment, Land, Water and Planning
▸ Murray-Darling Basin Authority (River Murray Operations and Living Murray program)
▸ NSW National Parks and Wildlife Service
▸ Parks Victoria
▸ Victorian Environmental Water Holder
▸ Yorta Yorta Nation Aboriginal Corporation

5.2.2 Gunbower Creek and Forest

Environmental values

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

Gunbower Creek is an integral part of the Gunbower system, providing important habitat for native fish (such as Murray cod, trout cod and freshwater catfish). Due to the high diversity of fish in the creek, it is considered to be a valuable refuge and source of fish for the recolonisation of surrounding waterways.

Social and economic values

Gunbower Creek and Forest are both valuable sites from a cultural and socioeconomic perspective. Local Aboriginal communities have had, and continue to have, a strong connection to the Gunbower Forest area. The forest provides social and economic values through timber production, apiculture (bee keeping), recreation and tourism. The creek supports recreational activities (such as boating, fishing and bird watching) and is a major carrier of irrigation water to the surrounding productive lands.

Environmental watering objectives in Gunbower Creek and Forest
Improve the resilience of wetland plant life and help river red gums recover from damage they experienced in the Millennium Drought
Provide feeding, breeding and refuge habitat for waterbirds including colonial nesting species
Maintain populations of small-bodied fish species in forest wetlands and support the life cycles of large and small-bodied fish in Gunbower Creek
Use flows to connect Gunbower Forest to Gunbower Creek enabling fish, insects, crustaceans, molluscs, worms and carbon to move between them, supporting the life cycle of Gunbower's native fish

System overview

Gunbower Forest is a large flood-dependent forest situated on the River Murray floodplain in northern Victoria between Torrumbarry and Koondrook. Covering 19,450 ha, it is bounded by the River Murray to the north and Gunbower Creek to the south. It is an internationally significant site under the Ramsar Convention and forms part of the Living Murray Gunbower-Koondrook-Perricoota 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 over the long term. This has affected the extent and condition of habitat and the health of dependent animal communities.

Gunbower Creek is managed primarily as an irrigation carrier and supplies the Torrumbarry Irrigation Area from the River Murray. The highly regulated nature of Gunbower Creek has changed the creek's hydrology, resulting in significant ecological impacts including impacts on native fish populations. Environmental water is used to improve flows in the creek to support fish migration and breeding, and to promote other ecological processes. Flows linking the creek to the Gunbower Forest floodplain can be restored through environmental water and are considered vital to enhance ecosystem functioning (such as carbon exchange).

Structural works under the Living Murray program in the middle and lower forest were 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 under natural conditions. The works enable efficient watering of the forest, through Gunbower Creek, to maintain wetland and floodplain condition.

Recent conditions

Gunbower Forest has received three years of consecutive flooding through both natural and managed events. From late May to early December 2014, the largest environmental watering ever undertaken at Gunbower Forest was delivered through the Hipwell Road channel regulator. Environmental water was delivered to improve vegetation condition, provide feeding habitat for waterbirds and enable native fish movement and carbon and nutrient cycling

between the creek and forest. The delivery also facilitated commissioning of the newly constructed infrastructure.

A total of 98 gigalitres (GL) of consumptive water was delivered through the Hipwell Road channel, inundating about 3,800 ha of the forest. About 50 GL of this nutrient and carbon rich water was returned to the River Murray, some via Gunbower Creek.

At least 2,500 ha of the river red gums in Gunbower Forest have now received flooding in four of the past ten years: in three of these years by natural floods. Field observations showed that the river red gums have responded with a flush of new growth. Follow-up watering is still required to assist canopies to thicken and continue to recover from the Millennium Drought.

Wetland plants responded strongly, with diversity increasing significantly when compared to previous surveys. Two threatened species—wavy marshwort and river swamp wallaby-grass—responded particularly well to the environmental watering.

The high-value permanent and semipermanent wetlands in the lower part of Gunbower Forest have provided critical refuge areas for waterbirds and source populations of vegetation. The importance of these areas was shown by the strong response to the 2014 environmental watering. A large number of waterbirds utilised the resources in the wetlands for feeding and breeding during the 2014 watering event. However, no significant colonial waterbird breeding was recorded.

Environmental water was provided through Gunbower Creek to support native fish in autumn and winter, during the off-irrigation season. Traditionally, the creek is drawn down to a series of disconnected deep pools at the end of the irrigation season, which is now understood to be a major factor limiting the survival of juvenile fish, particularly Murray cod. Providing environmental flows during this period enables continued connectivity between habitats and food resources to support native fish species.

Strong recruitment of Murray cod in Gunbower Creek was observed through monitoring in 2014, corresponding to the delivery of environmental watering intended specifically to trigger spawning of Murray cod in spring and early summer 2013–14. Despite this, the overall Murray cod population in Gunbower Creek requires ongoing environmental management for it to recover and become self-sustaining in the long term.

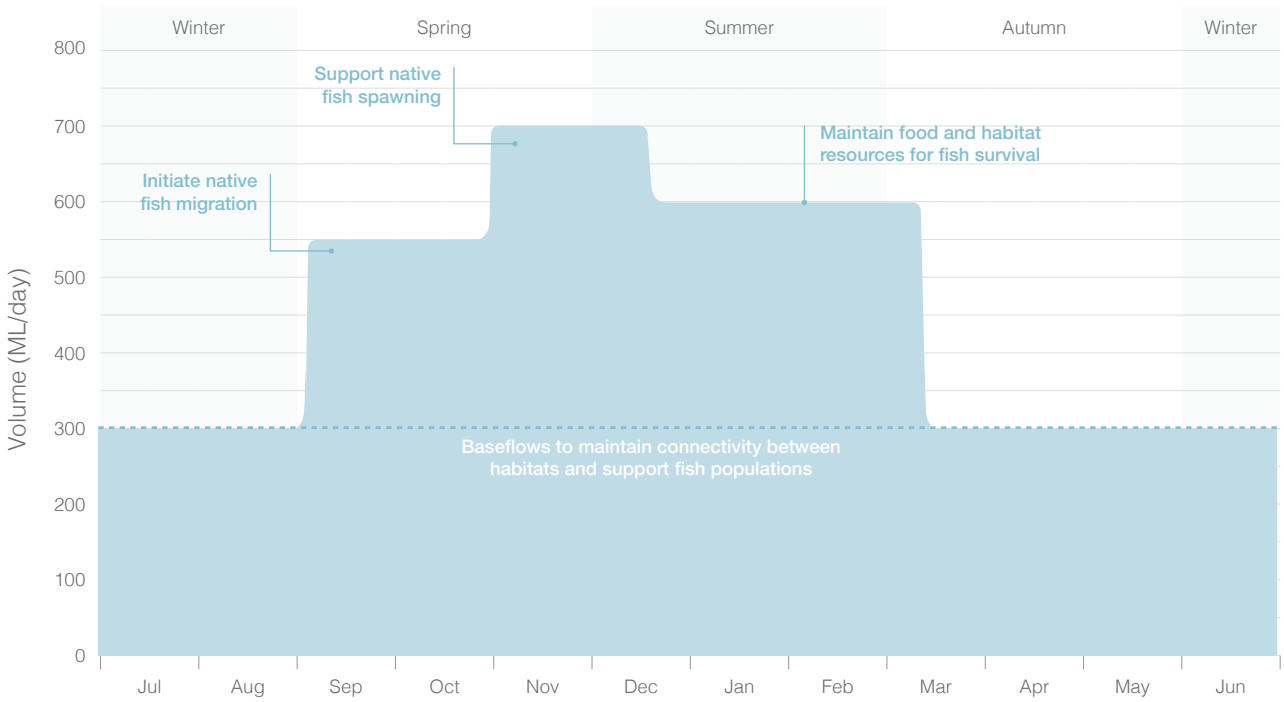
Scope of environmental watering

Potential environmental watering actions and their environmental objectives are shown in Table 5.2.4 and illustrated in Figure 5.2.2.

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

Potential environmental watering	Environmental objectives
Gunbower Forest	
Winter/spring/summer watering of Reedy Lagoon and Black Swamp (top-up flows as required during July–December)	▸ Maintain the health and resilience of vegetation communities in permanent wetlands ▸ Maintain suitable feeding and refuge habitat for waterbirds
Winter/spring/summer watering of Reedy Lagoon, Black Swamp, Little Reedy Lagoon wetland complex and Little Gunbower complex (top-up flows as required during July–December)	▸ Maintain/enhance the health and resilience of vegetation communities in permanent and semipermanent wetlands ▸ 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 if one is triggered naturally
Winter/spring inundation of Gunbower Forest floodplain, floodrunners and wetlands (variable flow rates to maintain appropriate inundation extent for 2–5 months during June–September)	▸ 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 if one is triggered naturally
Gunbower Creek	
Summer/autumn/winter baseflows (up to 300 ML/day between January and August)	▸ Maintain food and habitat resources for native fish including the recently recruited Murray cod in Gunbower Creek ▸ Maintain native fish access to resources
Spring/summer high flows (targeting a gradual increase in flow up to 700 ML/day including various periods of stable flow during August–January)	▸ Promote conditions for spawning and larvae survival
Connectivity flows (manipulation of Gunbower Creek regulators to provide lateral connectivity during forest watering)	▸ Carbon transfer and lateral fish movement between Gunbower Forest and Gunbower Creek

Figure 5.2.2 Potential environmental watering in Gunbower Creek



Note: This figure is for illustrative purposes only. Scheduling and delivery of particular watering actions within the stated timeframes will vary.

Scenario planning

Table 5.2.5 outlines the potential environmental watering and expected water usage under a range of planning scenarios.

The scale of the floodplain watering in Gunbower Forest will be determined by the preceding climatic conditions, capacity, and environmental water availability.

If natural flooding occurs, or sufficient environmental water is available, the provision of follow-up floodplain watering in Gunbower Forest remains the priority. This will continue to build resilience and improve condition of the floodplain ecosystem still recovering from the Millennium Drought, and promote lateral connectivity between the forest, creek and the Murray system. Alternatively, if the floodplain watering action is not undertaken in 2015–16, environmental water delivery will target key permanent and semipermanent wetlands in Gunbower Forest.

If a significant bird breeding event is triggered, environmental water may be delivered to assist in maintaining an appropriate inundation depth and area to support the waterbirds to fledging.

As Gunbower Creek is a highly regulated system, natural conditions do not greatly influence the objectives or flow requirements in the system. Environmental water management will aim to provide sufficient habitat and food resources for native fish throughout the year (particularly important during autumn/winter), promote opportunities for breeding and larval survival, and provide lateral and longitudinal connectivity to support fish movement on and off the floodplain.

Potential watering in Gunbower Creek and Forest remain the same in dry, average and wet scenarios. Under wetter scenarios less environmental water is expected to be required to achieve the same ecological objectives, due to the contribution of natural inflows. In a drought scenario, environmental watering will focus on providing critical flows to ensure the survival of key threatened species (such as Murray cod).

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	▸ Natural inflows into Gunbower Forest unlikely	▸ Natural inflows into Gunbower Forest are likely in winter/spring but unlikely to be significant	▸ Overbank flows may occur in winter/spring
Potential environmental watering	▸ Top-up watering of Reedy Lagoon and Black Swamp ▸ Gunbower Creek baseflows (winter period only)	▸ Top-up watering of Reedy Lagoon, Black Swamp, Little Reedy Lagoon wetland complex and Little Gunbower complex ▸ Winter/spring inundation of Gunbower Forest floodplain, floodrunners and wetlands ▸ Gunbower Creek summer/autumn/winter baseflows ▸ Gunbower Creek spring/summer high flows ▸ Gunbower Creek connectivity flows ▸ Support bird breeding if triggers are met		
Possible volume of environmental water required to meet objectives[1]	▸ 8,000 ML	▸ 49,600 ML	▸ 49,600 ML	▸ 44,600 ML

1 Represents the estimated volume of water required to underwrite the losses associated with the delivery of consumptive use water en route (with the exception of discrete wetland watering actions).

Risk management

In preparing its seasonal watering proposal, North Central CMA considered and assessed risks and identified mitigating strategies relating to the implementation of environmental watering. Risks and mitigating actions are continually reassessed by program partners throughout the water year (see section 1.4.4).

Engagement

The North Central CMA consulted key stakeholders when preparing the seasonal watering proposal for Gunbower Creek and Gunbower Forest. Table 5.2.6 shows these stakeholders.

Seasonal watering proposals are informed by longer-term regional waterway strategies, environmental water management plans and environmental flow studies, which incorporate environmental, cultural, social and economic considerations.

Table 5.2.6 Key stakeholders engaged in the development of the Gunbower Creek and Forest seasonal watering proposal

Stakeholder engagement
▸ Commonwealth Environmental Water Office ▸ Gannawarra Shire Council, Progress Association and Murray Tourism Board ▸ Gunbower Island Community Reference Group (with representatives of the Progress Association, bird observers and irrigators, and general community members) ▸ Gunbower Operations Advisory Group (with representatives of Goulburn-Murray Water; Parks Victoria; Department of Environment, Land, Water and Planning [regional]; Vic Forests; State Forests New South Wales, North Central CMA; Murray-Darling Basin Authority; the Commonwealth Environmental Water Holder; and VEWH) ▸ Gunbower Technical Working Group (with representatives of Department of Environment, Land, Water and Planning [Threatened Flora and Fauna]; Goulburn Broken CMA; and specialist fish, vegetation and bird consultants and ecologists) ▸ North Central CMA Natural Resource Management Committee, an advisory group to the North Central CMA Board comprising regional community members ▸ Victorian Environmental Water Holder ▸ Yorta Yorta and Barapa Barapa Traditional Owners

5.2.3 Central Murray wetlands

Environmental values

The wetlands within the central Murray system are considered highly significant, supporting several vulnerable or endangered species including the Murray hardyhead fish, the Australian painted snipe and the growling grass frog. The wetlands provide habitat for many threatened bird species listed under legislation and international agreements, including the great egret and white-bellied sea eagle. There are several internationally recognised, Ramsar-listed wetlands within the system including Lake Cullen, Hird Swamp and Johnson Swamp, while many of the others are of regional significance.

Social, cultural and recreational values

The Barapa Barapa and Wamba Wamba Nations are the Traditional Owner groups of the central Murray wetlands. The area is considered one of the most archaeologically important areas of Victoria with numerous documented middens, mounds, artefacts, scar trees and surface scatters.

The wetlands are used extensively for recreational activities including bird watching, bushwalking and duck hunting in some wetlands. Tourism to the region supports the local economy and other indirect economic benefits are derived from groundwater recharge and carbon storage that the wetlands support.

Environmental watering objectives in central Murray wetlands
Rehabilitate river red gum and wetland plant communities Provide appropriate wetting and drying conditions that support seed germination, seedling survival and recruitment including semi-aquatic plant species in damp areas of wetlands
Provide habitat for waterbird resting, feeding and breeding
Maintain habitat for the critically endangered Murray hardyhead fish
Provide habitat for the endangered growling grass frog

System overview

The central Murray wetland system consists of ten wetlands on the River Murray floodplain. Nine of these can receive environmental water: Lake Cullen, Hird Swamp, Johnson Swamp, Round Lake, McDonalds Swamp, Lake Elizabeth, Lake Murphy, Richardsons Lagoon and the Wirra-Lo wetland complex. All of these are wetlands of regional significance.

The central Murray wetlands are almost wholly contained within the Torrumbarry Irrigation Area. As this 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 flooding and rely on the provision of environmental water to maintain their ecological character and health.

Guttrum and Benwell forests are a regionally significant wetland system and border the River Murray. There is currently no permanent infrastructure in either forest for the delivery of environmental water although some semipermanent wetlands can be watered via temporary pumping from the River Murray.

Recent conditions

Low rainfall and high temperatures, and barriers that prevent natural runoff (such as channels, roads and levees), meant that minimal natural inflows were received in the central Murray wetlands during 2014–15. Environmental water was the only water source provided during 2014–15.

Environmental watering in 2014–15, included top-ups flows to Round Lake and Lake Elizabeth to maintain and establish suitable conditions for the Murray hardyhead fish species; and to Hird Swamp (west), Lake Murphy and McDonalds Swamp to support a diversity of waterbirds and other animal and plant species typical of temporary freshwater marshes. A partial fill was provided to Johnson Swamp to assist in managing ecological risks associated with expected early-season capacity constraints in 2015–16, and to the Wirra-Lo wetland complex to improve vegetation condition.

Two of the wetlands in the central Murray system were dried in 2014–15: Richardsons Lagoon and Lake Cullen. A drying regime for these wetlands is important to help promote germination and establishment of vegetation in and around the wetland, and also to promote productivity and provide a food source for wading waterbirds.

Round Lake remained permanently inundated during the season to support the resident Murray hardyhead population. Surveys in November 2014 did not detect any Murray hardyhead individuals, unlike surveys in previous years. However, opportunistic sightings of this species were noted outside of the formal surveys. This result may reflect the difficulties associated with sampling for this species, or simply reflect the natural boom and bust population cycles.

An increase in waterbird species was recorded at Round Lake, Lake Murphy, McDonalds Swamp and Lake Elizabeth. This included several significant species (such as the Victorian *Flora and Fauna Guarantee Act 1988* listed Caspian tern, blue-billed duck, white-bellied sea eagle and brolga). Other threatened species such as the musk duck, hardhead and Australasian shoveler were recorded at the wetlands.

River red gum saplings established after the 2010–11 floods at several wetlands show positive signs of healthy tree condition.

Hird Swamp west received a top-up in late spring/early summer. Upon review of the environmental watering response (including a low presence of waterbirds) and additional research and knowledge on cumbungi and cane grass, the watering was adapted and further deliveries did not occur for the remainder of the water year. The commencement of the drying phase at Hird Swamp provided significant feeding habitat for wading and foraging waterbirds, supported juvenile river red gum growth and will also assist in reducing the growth of cumbungi and common reed. These reeds currently cover a large portion of the wetland (a combined total of 37 percent) and threaten habitat diversity. This change in water regime will ensure better environmental outcomes for the long-term health of the wetland, including for its waterbirds.

A drying phase was completed at Richardsons Lagoon (one year duration) in 2014–15 with a small amount of water still present in the centre of the wetland. Despite low water levels, birds (such as the white-faced heron, black-fronted dotterel and whistling kite) were recorded visiting the wetland in February 2015.

Guttrum and Benwell forests have not received natural inflows since the heavy rains and consequent high flows in the River Murray in 2010–11. Although the natural inundation assisted the forest to recover from the Millennium Drought, recent observations suggest that the forests are still in a recovery phase.

Scope of environmental watering

Potential environmental watering actions (including wetland drying) and their environmental objectives are shown in Table 5.2.7.

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

Potential environmental watering	Environmental objectives
Wetland watering	
Round Lake (top-up flows as required to maintain water quality targets)	▸ Maintain habitat for Murray hardyhead fish species ▸ Maintain suitable waterbird habitat
Lake Elizabeth (top-up flows as required to maintain water quality targets)	▸ Provide conditions suitable for Murray hardyhead fish species translocation ▸ Support submerged salt-tolerant aquatic plant assemblage
Johnson Swamp (fill in winter/spring and provide top-ups if required)	▸ Promote mosaic of plant communities including lignum and black box communities ▸ Provide an open water habitat to support a diverse range feeding and breeding habitats for waterbirds
Richardsons Lagoon (fill from empty in winter/spring and provide top-ups if required)	▸ Promote a variety of vegetation communities (such as river red gum, black box and low sedgy wetlands) that support water-dependent species including fish, waterbirds, frogs and turtles
McDonalds Swamp (fill from empty in autumn and provide top-ups if required)	▸ Maintain a diverse vegetation community by supporting recruitment of young river red gums and reducing coverage of common reed and cumbungi communities through environmental water management
Wirra-Lo wetland complex (fill in winter/spring and provide top-ups if required)	▸ Rehabilitate river red gum and aquatic vegetation communities, providing habitat for the growling grass frog and a diversity of waterbirds
Guttrum and Benwell forests (semipermanent wetlands only; fill in winter/spring and provide top-ups if required)[1]	▸ Rehabilitate semipermanent wetland vegetation communities; provide feeding and breeding habitat for waterbird species
Wetland drying	
Hird Swamp, Lake Cullen and Lake Murphy (drawdown and drying)	▸ These wetlands will not be actively watered during 2015–16 ▸ The drying will assist in maintaining a diversity of habitats to support a wide range of wetland-dependent birds and animals, and promote the growth and establishment of vegetation in and surrounding the wetland

1 Guttrum and Benwell forests contain wetlands that may receive environmental water in 2015–16 pending further investigation and stakeholder engagement by North Central CMA. Infrastructure projects for Guttrum and Benwell forests are being assessed as part of the Sustainable Diversion Limit Offset component of the Murray-Darling Basin Plan. Until works are approved and completed, environmental watering will only consider impermanent wetlands that can receive water from temporary pumping of water from the River Murray.

Scenario planning

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

Landscape-scale planning for these wetlands has been undertaken by the North Central CMA to optimise the wetland watering regimes over multiple years. An important consideration in this planning includes ensuring that there is a diversity of habitat types available across the region to support waterbirds and other water-dependent fauna at any point in time.

In a given year, multiple wetlands may require environmental water at the same time. Interannual planning helps to manage the risk of increased pressure on environmental water resources, particularly if there is a return to drought conditions. It also helps support waterbird populations by ensuring that suitable habitat for breeding, feeding and nesting is available across northern Victoria.

The wetlands of highest priority for environmental water management in the central Murray wetlands are Round Lake and Lake Elizabeth. Round Lake currently supports the critically endangered Murray hardyhead fish species and is considered to have the only stable population in the Kerang area. Lake Elizabeth has been prioritised as a recipient of environmental water to maintain suitable conditions for the possible translocation of Murray hardyhead in 2015–16. It is essential that the wetlands are maintained so that future stocking and translocation programs can be implemented to prevent the regional loss of the species.

In drier scenarios, environmental water will be required to fill and maintain water depth in wetlands, to support the needs of wetland-dependent vegetation, fish and bird species. As conditions become wetter, catchment inflows are expected to contribute to water levels in the wetlands but environmental water will be required to maintain water depth to support waterbird breeding and vegetation condition.

No environmental water is planned to be delivered to Lake Cullen, Lake Murphy or Hird Swamp in 2015-16, as these wetlands are in a dry or drying phase. Hird Swamp and Lake Murphy require a drying phase to promote a diversity of habitat for waterbirds. Lake Cullen is scheduled for watering in 2016–2017. If wet catchment conditions eventuate and natural inundation of these wetlands occurs, water levels may need to be maintained to reduce the potential detrimental impact from a short, shallow inundation. An assessment will be undertaken to inform the most appropriate management option considering the timing, extent and duration of the natural inundation.

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 runoff and unregulated flows into the wetlands is unlikely	▸ Catchment runoff and unregulated flows into the wetlands is unlikely	▸ Some catchment runoff and unregulated flows into the wetlands is likely, particularly during winter/spring	▸ Catchment runoff and unregulated flows into the wetlands may significantly contribute to water levels in the wetlands, particularly during winter/spring
Potential environmental watering	▸ Round Lake ▸ Lake Elizabeth ▸ Johnson Swamp ▸ Richardsons Lagoon ▸ McDonalds Swamp ▸ Wirra-Lo wetland complex ▸ Guttrum and Benwell forests			
Possible volume of environmental water required to meet objectives	▸ Up to 11,000 ML			

Risk management

In preparing its seasonal watering proposal, North Central CMA considered and assessed risks and identified mitigating strategies relating to the implementation of environmental watering. Risks and mitigating actions are continually reassessed by program partners throughout the water year (see section 1.4.4).

Engagement

The North Central CMA consulted key stakeholders when preparing the seasonal watering proposal for the central Murray wetlands. Table 5.2.9 shows these stakeholders.

Seasonal watering proposals are informed by longer-term regional waterway strategies, environmental water management plans and environmental flow studies, which incorporate environmental, cultural, social and economic considerations.

Table 5.2.9 Key stakeholders engaged in the development of the central Murray wetlands seasonal watering proposal

Stakeholder engagement
▸ Birdlife Australia
▸ Central Murray Wetlands Environmental Water Advisory Group (comprising community members, interest groups, North Central CMA project staff, Board and Natural Resource Management Committee representatives)
▸ Commonwealth Environmental Water Office
▸ Community members
▸ Department of Environment, Land, Water and Planning
▸ Field and Game Australia
▸ Gannawarra Shire Council
▸ Goulburn-Murray Water
▸ North Central CMA Natural Resource Management Committee, an advisory group to the North Central CMA Board comprising regional community members
▸ Parks Victoria
▸ Swan Hill Rural City Council
▸ Victorian Environmental Water Holder

5.2.4 Hattah Lakes

Environmental values

Hattah Lakes is recognised for its waterbird breeding habitat and is a high-value drought refuge for wetland-dependent waterbirds and other threatened plants and animals in the Mallee. The lakes provide important habitat for colonial waterbird species including the spoonbill, egret, night heron, bittern, and for migratory bird species. Nine fish species have been reported present in the lakes; five of these have conservation significance in Victoria including the eel-tailed catfish and fly-specked hardyhead.

Flood-dependent vegetation at Hattah Lakes ranges from wetland communities that require frequent flooding to those that require only periodic inundation (such as lignum and black box-dominated communities). The lakes support 115 significant plant species. One of these species, winged peppercress is listed as nationally endangered under the *Environmental Protection and Biodiversity Conservation Act 1999*.

Social and economic values

The Hattah Lakes hold great significance to Traditional Owners in the region, who have a continuing connection to the lakes and surrounding areas. There are more than 1,000 registered sites of significance including burial sites, scar trees and shell middens.

Social and recreational activities undertaken at the lakes include nature-based tourism such as camping, picnicking, four-wheel driving, trail bike riding, hunting, horse riding, walking, bird watching, fishing and boating. Parks Victoria open sections of the Murray-Sunset National Park throughout the year and wood collection and apiary (bee-keeping) are common practices, with licences issued by the Department of Environment, Land, Water and Planning.

Environmental watering objectives for the Hattah Lakes	
	Restore 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 species such as the spoonbill and egret
	Maintain high-quality habitat for native fish in wetlands Use flows to connect the lakes to the river so large-bodied fish (including Murray cod and perch) can move, feed and breed

System overview

The Hattah Lakes are adjacent to the River Murray between Mildura, Robinvale and Ouyen. They consist of over 20 semipermanent freshwater lakes that cover an area of 48,000 ha and form part of the Hattah-Kulkyne National Park. The ecology of the lakes and floodplain communities are strongly influenced by their flooding regimes.

Under natural conditions, the lakes were fed from high River Murray flows and influenced by all major Murray tributaries upstream of the Murrumbidgee; the lakes then held water for several years after floods receded. However, these events have been significantly reduced with river regulation and water extraction.

Large-scale engineering works were completed in 2013 and now allow water to be pumped from the Murray system into the Hattah Lakes to support the important environmental values in the system. The new infrastructure includes permanent pumps that can deliver up to 1,000 ML per day to the floodplain and water retention structures that can hold water on the floodplain and regulate the drawdown.

Recent conditions

Environmental water was delivered to Hattah Lakes in 2013–14 and 2014–15, with all the lakes in the Hattah system (including Lake Kramen) receiving water.

The environmental watering contributed to meeting a range of ecological objectives for the system, particularly aiming to inundate fringing river red gum and black box woodlands, which have been in a stressed condition following the Millennium Drought.

Environmental watering facilitated nutrient exchange between the floodplain and lakes, providing a productivity pulse to the wetlands. The plants, fish and birds using the lakes have thrived and reproduced in response to the watering. With the ability to provide water more frequently to the floodplain, it is expected that the condition of the floodplain vegetation will continue to improve.

Besides the improved condition of red gum and black box from the last two watering events, one of the significant events observed was cormorant breeding on the lakes for the second consecutive year. Cormorants and darters have been present in the system in small numbers in recent years but this is the first time breeding has been observed in about ten years.

The watering provided connectivity between the lakes, allowing fish to move in and out of the lake system. Three large-bodied native species were recorded in the lakes (Murray cod, golden perch and silver perch).

Scope of environmental watering

Potential environmental watering actions and their environmental objectives are shown in Table 5.2.10.

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

Potential environmental watering	Environmental objectives
Winter/spring inundation of semipermanent wetlands (provide top-up flows as required targeting a water level of 42.5 m Australian height datum July–November)	▸ Maintain deeper water for piscivorous waterbird breeding events ▸ Maintain potential breeding habitat for fish including golden perch ▸ Provide connectivity between the Hattah Lakes system and the River Murray channel
Winter/spring fresh in Chalka Creek south	▸ Provide connectivity between the main channel and the Hattah Lakes

Hattah Lakes, by Mallee CMA

Scenario planning

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

Following two consecutive years of watering, the ecological requirements for the red gum forest and woodlands have been met and both communities now need time to dry and allow new understory to develop. Therefore, the priority for the Hattah Lakes in 2015–16 is to provide top-ups to the semipermanent and temporary wetlands to maintain habitat to support both waterbird and fish breeding.

Under a drought scenario, environmental watering will focus on protecting key ecological functions in the lakes, such as connectivity for native fish to the River Murray, requiring a much smaller volume compared to dry, average and wet conditions. Under the wetter scenarios, potential environmental watering will build on natural cues to maintain and improve the ecological health of the lakes and their river red gum, black box and wetland vegetation communities by increasing the extend and duration of inundation.

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

Planning scenario	Drought	Dry	Average	Wet
Expected river conditions	▸ Unregulated flow periods very unlikely ▸ No natural inflows expected into wetlands or floodplain	▸ Low probability of small unregulated flows in spring ▸ No natural inflows expected into wetlands or floodplain	▸ Likely unregulated flows in winter/spring ▸ Some wetlands and the floodplain may fill from natural inflows	▸ High probability of moderate-to-large unregulated flows during winter/spring ▸ Wetlands and floodplain may fill from natural inflows
Potential environmental watering	▸ Winter/spring fresh in Chalka Creek south ▸ Winter/spring inundation of semipermanent wetlands (partial fill)	▸ Winter/spring fresh in Chalka Creek south ▸ Winter/spring inundation of semipermanent wetlands ▸ Winter/spring inundation of temporary wetlands (partial fill)	▸ Winter/spring fresh in Chalka Creek south ▸ Winter/spring inundation of semipermanent wetlands ▸ Winter/spring inundation of temporary wetlands	▸ Winter/spring fresh in Chalka Creek south ▸ Winter/spring inundation of semipermanent wetlands ▸ Winter/spring inundation of temporary wetlands
Possible volume of environmental water required to meet objectives	▸ 10,000 ML	▸ 15,000 ML	▸ 20,000 ML	▸ 30,000 ML

Risk management

In preparing its seasonal watering proposal, Mallee CMA considered and assessed risks and identified mitigating strategies relating to the implementation of environmental watering. Risks and mitigating actions are continually reassessed by program partners throughout the water year (see section 1.4.4).

Engagement

Mallee CMA consulted key stakeholders when preparing the seasonal watering proposal for the Hattah Lakes. Table 5.2.12 shows these stakeholders.

Seasonal watering proposals are informed by longer-term regional waterway strategies, environmental water management plans and environmental flow studies, which incorporate environmental, cultural, social and economic considerations.

Table 5.2.12 Key stakeholders engaged in the development of the Hattah Lakes seasonal watering proposal

Stakeholder engagement
▸ Commonwealth Environmental Water Office ▸ Community reference groups (provide input and engagement to Mallee CMA's initiatives with representation of Traditional Owners and the Living Murray Icon Site Manager groups) ▸ Goulburn-Murray Water ▸ Lower Murray Water ▸ Mallee CMA community committees (advisory groups to the Mallee CMA Board with community representatives) ▸ Murray-Darling Basin Authority ▸ New South Wales Office of Water ▸ Parks Victoria ▸ SA Water ▸ Victorian Environmental Water Holder

5.2.5 Lower Murray wetlands

Environmental values

The lower Murray wetlands span more than 700 km of linear floodplain along the River Murray. The vast area makes the wetlands regionally significant because the individual wetlands, creeks and billabongs identified for watering contain a diverse range of values that vary in composition and quality.

The dominant tree species found at most wetland sites are river red gum and black box. These trees form significant forests on the floodplain which provide habitat, particularly for birds, reptiles and mammals. River red gums are tolerant to regular flooding, and black box less so, and a regular watering regime is required to maintain both species in good health. Many sites also contain lignum, a dominant shrub that provides habitat for small woodland birds.

The wetland types are varied. Depending on their location in the landscape, the interaction with groundwater and their management history, wetlands may be permanent, temporary, fresh or saline. These differences in water regime and water quality provide a diverse range of habitats for different plants and animals. For example, permanent, saline wetlands (such as Brickworks Billabong) provide vital habitat for the critically endangered Murray hardyhead fish. Sandilong Creek is a permanent freshwater wetland that contains the endangered freshwater catfish. In contrast to permanent wetlands, temporary freshwater wetlands (such as Nyah floodplain and Neds Corner) may be filled and dried over the course of one to two years. These wetlands provide short-term conditions that allow wetland plants to grow, spread and provide feeding and breeding habitat for frogs, turtles and birds.

Social and economic values

Camping, fishing and other water-based recreational activities are popular along the River Murray, including at some wetlands in the lower Murray system. Increases in waterbird abundance resulting from environmental watering in the landscape provide improved opportunities for bird watching and hunting. Increased visitation is important for the economy of small communities and nearby towns. Aboriginal culture is strongly linked to the floodplain of the River Murray, which for many thousands of years would have maintained a concentrated population due to the abundant resources it provided.

Environmental watering objectives in the lower Murray wetlands	
	Increase the diversity, extent and abundance of wetland plant life
	Provide feeding and breeding habitat for a range of waterbird species including threatened and migratory species and colonial species (such as the egret)
	Improve water quality and increase habitat for fish
	Improve the condition of river red gums, black box and lignum to provide habitat for large animals (such as lace monitors and bats)

System overview

The lower Murray wetlands are distributed on the River Murray floodplain between Swan Hill and the South Australian border. They include creeks, wetlands and floodplains that are ecologically important and reflect the natural character and attributes of the River Murray floodplain. Some of these wetlands and waterways can be managed with environmental water.

The regulation and diversion of River Murray flows has substantially altered the hydrology of the lower Murray wetlands. Compared to conditions before river regulation, the frequency and duration of high river flows that are needed to activate anabranches and fill billabongs and floodplain land have been substantially reduced. This long-term change to the water regime has caused a decline in the environmental values of floodplain wetland sites.

Environmental water can be delivered to the lower Murray wetlands through a combination of direct pumping from the River Murray and through use of irrigation supply infrastructure at some wetlands. All the wetlands can be managed independently of each other.

Recent conditions

The last time there were sustained high flows in the River Murray—sufficient to flood vast areas of wetlands and floodplains—was in 2010 and 2011. Those floods came at the end of the Millennium Drought and helped improve ecosystem health after a long period of environmental stress. Since then, rainfall in the region has been consistently low and high river flows have mostly been absent, so wetlands have relied on the delivery of environmental water to build on the benefits derived from the flooding and help maintain their environmental condition.

In 2014–15, lower Murray wetlands watered included Sandilong Creek and Billabong, Cardross Lakes, Brickworks Billabong, Woorlong wetlands, Psyche Bend Lagoon, Burra Creek North, Burra Creek South, Bridge Creek, Bullock Swamp, Lake Koorlong, Neds Corner Central, Neds Corner East, Nyah floodplain and Vinifera floodplain.

This watering achieved a range of positive outcomes. At several sites, environmental watering supported populations of the critically endangered Murray hardyhead by maintaining water quality. In March 2015, 2,500 Murray hardyhead were relocated to Brickworks Billabong. Watering of the billabong has maintained the condition of sea tassel, which is vital habitat for Murray hardyhead. At other floodplain sites (such as Vinifera floodplain and Nyah floodplain), there have been improvements in the condition of vegetation that provides habitat for terrestrial and aquatic animals.

Scope of environmental watering

Potential environmental watering actions and their environmental objectives are shown in Table 5.2.13.

Environmental watering will focus on maintaining and improving vegetation condition, habitat quality and availability throughout the wetlands, floodplains and waterways in the lower Murray region, and in some cases, rehabilitating 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	
Brickworks Billabong (top-up as required to maintain water quality targets)	▸ Maintain and improve the condition of aquatic vegetation and water quality for Murray hardyhead
Cardross Lakes (top-up as required to maintain water quality targets)	
Lake Koorlong (top-up as required to maintain water quality targets)	
Neds Corner Central and East (top-up in spring)	▸ Provide breeding and roosting habitat for colonial waterbirds
Dimases wetland (fill in autumn)	▸ Maintain and improve the health of river red gums ▸ Provide habitat for native fish following a drying phase in Butlers Creek
Cowanna Billabong (fill in winter)	
Butlers Creek (top-up in winter/spring)	
Psyche Bend Lagoon (fill in winter/spring, top-up in autumn and discharge return flows to the River Murray in line with agreed operation triggers)	▸ Provide freshwater inflows and flushing flows to reduce salinity levels and improve the condition and diversity of wetland vegetation, improving ecological function ▸ Establish aquatic vegetation and improve the condition of fringing vegetation, particularly lignum in the Woorlong floodplain ▸ Maintain adequate water levels to control the spread of cumbungi in Woorlong wetland ▸ Provide suitable habitat for native fish and frogs
Woorlong wetland (fill in autumn)	
Woorlong floodplain (fill in autumn)	
Outlet Creek (fill in winter/spring)	
Bullock Swamp (fill in winter/spring and discharge return flows to the River Murray in line with agreed operation triggers, if required)	
Liparoo West Billabong (fill in winter/spring)	▸ Maintain and improve the health of river red gum and black box and lignum
Carina Bend (fill in winter/spring)	
Margooya Lagoon (fill in spring)	▸ Improve river red gum condition ▸ Improve the native fish assemblage of the lagoon ▸ Restore submerged aquatic vegetation in the open water areas of the wetland
Lock 15 wetlands (fill in winter/spring)	▸ Maintain aquatic habitat and provide refuge for a range of aquatic fauna species ▸ Improve the productivity of connected riparian zones and wetlands ▸ Maintain resident populations of frogs and small fish in wetlands ▸ Provide reliable breeding and feeding habitat for waterbirds including colonial nesting species ▸ Restore floodplain productivity to maintain resident populations of vertebrate fauna including carpet python and insectivorous bats ▸ Contribute to the carbon requirements of the River Murray channel ecosystem

Potential environmental watering	Environmental objectives
Lake Powell (fill in spring)	▸ Provide productive lake habitat for waterbirds ▸ Restore floodplain productivity to maintain resident populations of vertebrate fauna including carpet python and insectivorous bats ▸ Promote emergent and semi-emergent aquatic vegetation in Burra Creek
Lake Carpul (fill in spring)	
Burra Creek North (fill in winter/spring)	
Burra Creek South (fill in winter/spring)	
Nyah floodplain (fill in winter)	▸ Improve condition and structure of wetland vegetation ▸ Provide seasonal feeding and reproductive opportunities for native fish ▸ Provide breeding habitat for waterbirds including colonial nesting species ▸ Restore floodplain productivity to maintain resident populations of vertebrate fauna including carpet python, sugar glider and grey-crowned babbler
Vinifera floodplain (fill in winter)	
Wetland drying	
Robertsons wetland, Catfish Lagoon, Spences Bend wetland, Liparoo East, Yungera wetland, Heywood Lake, Bridge Creek	▸ These wetlands will not be actively watered throughout 2015–16 ▸ Drying will assist in maintaining a diversity of habitats to support a wide range of wetland-dependent birds and animals and promote the growth and establishment of vegetation in and surrounding the wetland

Scenario planning

The lower Murray wetlands are still recovering from the Millennium Drought. The approach in 2015–16 is to continue recovery and build resilience to endure future dry conditions. Under a drought scenario, the highest-priority wetlands for environmental watering in the lower Murray area are Cardross Lakes, Lake Koorlong and Brickworks Billabong, as these sites currently support the critically endangered Murray hardyhead. Depending on seasonal conditions and water availability, remaining wetlands are proposed to receive environmental water, in line with their recommended watering regimes.

For some temporary wetlands, the desired wet phase has been achieved consistently in recent years. In these cases the wetlands will not be actively watered in 2015–16 and will be allowed time to dry (refer to Table 5.2.14). This will allow time for vegetation to germinate and establish, to increase the diversity of habitats available for aquatic plants and animals during the next wet phase. At the same time, the dry phase will provide opportunities for terrestrial animals to access resources within a temporarily dry wetland.

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

Psyche Lagoon, by Mallee CMA

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

Planning scenario	Drought	Dry	Average	Wet
Expected river conditions	▸ No unregulated flows in the River Murray year-round ▸ Wetlands rely on environmental water delivery		▸ Sustained periods of high flow in the River Murray in late winter and early spring will provide some opportunity for low-lying wetlands to be naturally inundated, however most wetlands will still rely on environmental water delivery	▸ Lengthy periods of high flows and floods with major spills from storages, resulting in widespread inundation of the floodplain and inundating most wetlands ▸ Some reliance on environmental water delivery to achieve target water levels
Potential environmental watering	▸ Brickworks Billabong ▸ Cardross Lakes ▸ Lake Koorlong	▸ Brickworks Billabong ▸ Cardross Lakes ▸ Lake Koorlong ▸ Neds Corner Central and East ▸ Nyah floodplain ▸ Vinifera floodplain	▸ Brickworks Billabong ▸ Cardross Lakes ▸ Lake Koorlong ▸ Neds Corner Central and East ▸ Nyah floodplain ▸ Vinifera floodplain ▸ Dimases wetland ▸ Psyche Bend Lagoon ▸ Cowanna Billabong ▸ Butlers Creek ▸ Woorlong wetland ▸ Woorlong floodplain ▸ Bullock Swamp ▸ Liparoo West Billabong ▸ Carina Bend ▸ Margooya Lagoon ▸ Lock 15 wetlands ▸ Lake Powell ▸ Lake Carpul ▸ Burra Creek North ▸ Burra Creek South	▸ Brickworks Billabong ▸ Cardross Lakes ▸ Lake Koorlong ▸ Neds Corner Central and East ▸ Nyah floodplain ▸ Vinifera floodplain ▸ Dimases wetland ▸ Psyche Bend Lagoon ▸ Cowanna Billabong ▸ Butlers Creek ▸ Woorlong wetland ▸ Woorlong floodplain ▸ Bullock Swamp ▸ Liparoo West Billabong ▸ Carina Bend ▸ Margooya Lagoon ▸ Lock 15 wetlands ▸ Lake Powell ▸ Lake Carpul ▸ Burra Creek North ▸ Burra Creek South ▸ Outlet Creek
Possible volume of environmental water required to achieve objectives	▸ 1,650 ML	▸ 3,000 ML	▸ 18,500 ML	▸ 19,100 ML

Risk management

In preparing its seasonal watering proposal, Mallee CMA considered and assessed risks and identified mitigating strategies relating to the implementation of environmental watering. Risks and mitigating actions are continually reassessed by program partners throughout the water year (see section 1.4.4).

Engagement

Mallee CMA has consulted stakeholders when preparing the seasonal watering proposal for the lower Murray wetlands. These stakeholders are shown in Table 5.2.15.

Seasonal watering proposals are informed by longer-term regional waterway strategies, environmental water management plans and environmental flow studies, which incorporate environmental, cultural, social and economic considerations.

Table 5.2.15 Key stakeholders engaged in the development of the lower Murray wetlands seasonal watering proposal

Stakeholder engagement
▸ Burra Creek South Proper landholder ▸ Burra Creek South Proper syndicate ▸ Commonwealth Environmental Water Office ▸ Lower Murray Water ▸ Mallee CMA Aboriginal Reference Group, an advisory committee to Mallee CMA comprising Indigenous representatives ▸ Mallee CMA Land and Water Advisory Committee, an advisory group to Mallee CMA comprising community members ▸ Murray-Darling Basin Authority ▸ Nangiloc Irrigation Association ▸ New South Wales Office of Water ▸ Parks Victoria ▸ Victorian Environmental Water Holder

5.2.6 Lindsay, Wallpolla and Mulcra islands

Environmental values

The Lindsay, Wallpolla and Mulcra island system includes semipermanent and ephemeral waterways and wetlands which support a range of vegetation types including river red gum and black box woodlands and lignum shrublands. The surrounding creeks and streams are important in maintaining flowing water habitat for fish species such as the iconic Murray cod. The island system also provides resources for the growth and breeding of another four fish species (freshwater catfish, silver perch, Murray-Darling rainbowfish and unspecked hardyhead) listed under the *Flora and Fauna Guarantee Act 1988*. When flooded, waterways and wetlands within this system provide important habitat for a range of wetland-dependent species including many waterbirds. Of these bird species, 40 are considered threatened in Victoria including the great egret and red-necked stint.

Social and economic values

The island floodplains are popular recreation sites for the local communities and camping, canoeing, bird watching, photography, fishing and four-wheel driving are all popular pursuits.

The floodplain and wetland systems still have many sites of Indigenous significance (such as shell middens, burial sites and scar trees). Lindsay Island is listed as a special protection area due to the presence of many archaeological sites. The floodplain and wetland systems continue to be places of significance for Traditional Owners and their Nations in the region.

Environmental watering objectives for Lindsay, Wallpolla and Mulcra islands
Increase the diversity, extent and abundance of wetland plant life
Provide feeding and breeding habitat for a range of waterbird species including threatened and migratory species and colonial species such as the egret
Increase abundance, diversity and movement of native fish; provide flows for large-bodied fish (including Murray cod and perch) to swim, feed and breed

System overview

Lindsay, Wallpolla and Mulcra islands cover over 26,100 ha of River Murray floodplain, forming part of the Chowilla floodplain and Lindsay–Wallpolla Island Living Murray icon site.

The islands are fed by high River Murray flows that are influenced by the upper Murray tributaries and flows in the Darling River. The islands are located in a reach of the River Murray that is highly regulated through a series of locks and weirs; locks 6–9 all affect the natural hydrology. A combination of large floods, structural works, weir manipulation and temporary pumping allow the islands to receive environmental water. Structural works have been completed at Mulcra, Wallpolla and Lindsay islands that can be used to control flow through the anabranches and manage water to specific wetlands (such as Lake Wallawalla).

Recent conditions

In 2013–14 and 2014–15, the newly-commissioned structures allowed water to be provided to the Mulcra Island floodplain, including some inundation of the fringing lignum shrublands.

Monitoring suggests there has been improvement in vegetation condition of watered areas although anecdotal observations suggest parts of the system are still stressed, with lignum and black box in some areas being in very poor condition.

Mulcra was the only island to receive environmental water in 2014–15 with around 6,300 ML delivered in spring and early summer. The delivery helped restore connectivity between the river and floodplain habitats and provided water to the higher elevation and severely stressed lignum communities. A range of waterbirds were recorded during the watering although species that feed on small fish were not present.

Wallpolla Island's Horseshoe Lagoon received about 400 ML of environmental water in late autumn 2014–15. The delivery aimed to assist in supporting the growth of aquatic plants and fringing vegetation.

The completion of infrastructure at Lindsay and Mulcra islands aims to improve flows in the upper reaches of the anabranches, improving fish passage and connectivity between the anabranches and the River Murray. Movement of both native and non-native fish has been recorded through the new infrastructure on the upper Potterwalkagee Creek, part of the Mulcra Island system.

Scope of environmental watering

Potential environmental watering actions and their environmental objectives are shown in Table 5.2.16.

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

Potential environmental watering	Environmental objectives
Lindsay Island	
Year-round baseflows through Mullaroo Creek and northern Lindsay River (up to 700 ML/day year-round)[1,2]	▸ Maintain native fish habitat
Spring fresh through Mullaroo Creek and Lindsay River including flows in the southern Lindsay River (up to 900 ML/day for 3 months during August–October)[1]	▸ Stimulate native fish movement and spawning
Winter/spring inundation of Lake Wallawalla (filling flows during August–October)	▸ Maintain condition of the lakebed herbland and provide opportunities for waterbird breeding and frogs
Mulcra Island	
Year-round baseflows through Potterwalkagee Creek (up to 100 ML/day year-round)[2]	▸ Maintain large-bodied fish habitat
Spring fresh through Potterwalkagee Creek (up to 300 ML/day for up to 3 months during August–October)	▸ Stimulate large-bodied native fish movement and spawning
Wallpolla Island	
Winter/spring inundation of Wallpolla East (filling flows during July–November)	▸ Increase diversity and extent of littoral zone vegetation ▸ Provide habitat for waterfowl

1 As well as targeting environmental benefits, watering actions in Lindsay Island are aimed at commissioning the new environmental water management structures with the final offtake at Mullaroo Creek planned to be commissioned in 2015–16.

2 Year-round baseflows in Mullaroo Creek, northern Lindsay River and Potterwalkagee Creek are typically provided by the delivery of consumptive water en route in the Murray system. Any additional losses associated with the deliveries will be met using environmental water.

Scenario planning

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

Specific flow rates and lock heights in the River Murray are required to facilitate environmental watering in many parts of Lindsay, Wallpolla and Mulcra islands. As such, it will depend on sufficient flows occurring down the River Murray. Under a wet scenario, high flows in the Murray system are likely to naturally inundate the wetlands or significantly contribute to achieving the desired watering regimes.

Under dry scenarios, environmental watering will focus on the provision of baseflows in the waterways and on low-level inundation of Lake Wallawalla to provide critical habitat for waterbirds and other water-dependent animal species. Under wetter scenarios, freshes are proposed to be delivered in waterways and wetland watering will be more extensive, building on wetter catchment conditions and expected high flows in the Murray system.

Mulcra Island, by Mallee CMA

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

Planning scenario	Drought	Dry	Average	Wet
Expected river conditions	▸ Unregulated flow periods very unlikely ▸ No natural inflows expected into semipermanent wetlands or the floodplain	▸ Low probability of small unregulated flows in spring ▸ No natural inflows expected into semipermanent wetlands or the floodplain	▸ Likely chance of unregulated flows in winter/spring ▸ Some wetlands and the floodplain may receive some natural inflows	▸ High probability of moderate-to-large unregulated flows during winter/spring ▸ Wetlands and the floodplain may receive some natural inflows
Potential environmental watering	▸ Year-round baseflows in the Mullaroo Creek, northern Lindsay River and Potterwalkagee Creek ▸ Winter/spring inundation of Lake Wallawalla	▸ Year-round Baseflows in the Mullaroo Creek and northern Lindsay River, and Potterwalkagee Creek ▸ Winter/spring inundation of Lake Wallawalla ▸ Winter/spring inundation of Wallpolla East	▸ Spring fresh through the Mullaroo Creek and Lindsay River ▸ Winter/spring inundation of Lake Wallawalla ▸ Spring fresh through Potterwalkagee Creek ▸ Winter/spring inundation of Wallpolla East	▸ Spring fresh & high flows through the Mullaroo Creek and Lindsay River ▸ Winter/spring inundation of Lake Wallawalla ▸ Spring fresh & high flows through Potterwalkagee Creek ▸ Winter/spring inundation of Wallpolla East
Possible volume of environmental water required to meet objectives[1]	▸ 2,000 ML	▸ 5,000 ML	▸ 10,000 ML	▸ 23,000 ML

1 Volume includes the estimated volume of environmental water required to underwrite the losses associated with the delivery of consumptive water en route (for flows within the Mullaroo Creek, Lindsay River and Potterwalkagee Creek)

Wallpolla, by Mallee CMA

Risk management

In preparing its seasonal watering proposal, Mallee CMA considered and assessed risks and identified mitigating strategies relating to the implementation of environmental watering. Risks and mitigating actions are continually reassessed by program partners throughout the water year (see section 1.4.4).

Engagement

The Mallee CMA has consulted stakeholders when preparing the seasonal watering proposal for the Lindsay, Wallpolla and Mulcra islands system. These stakeholders are shown in Table 5.2.18.

Seasonal watering proposals are informed by longer-term regional waterway strategies, environmental water management plans and environmental flow studies, which incorporate environmental, cultural, social and economic considerations.

Table 5.2.18 Key stakeholders engaged in the development of the Lindsay, Wallpolla and Mulcra islands seasonal watering proposal

Stakeholder engagement
▸ Commonwealth Environmental Water Office
▸ Goulburn-Murray Water
▸ Lower Murray Water
▸ Mallee CMA Aboriginal Reference Group, an advisory committee to Mallee CMA comprising Indigenous representatives
▸ Mallee CMA Land and Water Advisory Committee, an advisory group to Mallee CMA comprising community members
▸ Murray-Darling Basin Authority
▸ New South Wales Office of Water
▸ Parks Victoria
▸ SA Water
▸ Victorian Environmental Water Holder

Mulcra Island, by Mallee CMA

5.3 Ovens system

Waterway manager – North East Catchment Management Authority

Storage manager – Goulburn-Murray Water

Environmental water holder – Commonwealth Environmental Water Holder

Environmental values

The Ovens River system supports a wide range of self-sustaining native fish populations including Murray cod, trout cod, golden perch and fly-specked hardyhead. The Buffalo River is important for large fish species during part of their breeding cycle while trout cod are found as far up the King River as Whitfield. The Ovens system has been the focus of a successful recovery project for trout cod, with efforts to reintroduce Macquarie perch currently underway.

Frogs (such as the giant bullfrog and growling grass frog) are abundant in the lower Ovens River and associated wetlands and in the King River upstream of Cheshunt. The lower wetlands support birds such as egrets, herons, cormorants, bitterns and treecreepers while the river-red-gum-dominated riparian vegetation along the rivers is among the healthiest examples in north-east Victoria.

Social and economic values

Recreational activities include fishing, boating, kayaking, water skiing, swimming and bushwalking, while irrigation supports the food and wine industries that attract many tourists to the region. Lake Mulwala, at the confluence of the Murray and Ovens rivers, is another tourist drawcard. There are also significant Indigenous cultural heritage values with scar trees and artefact scatters as the physical evidence of Aboriginal people living along the river. The Ovens River continues to be a place of significance for Traditional Owners and their Nations in the region.

Environmental watering objectives in the Ovens system
Provide flow for native fish to move between pools and over rocky or shallow parts of the river
Maintain the form of the river bank and channel, plus a range of different river bed surfaces to support all stream life. Scour silt build-up and clean cobbles in river bed pools to maintain habitat for native plants and animals
Maintain water quality for all river life
Provide habitat for a wide range of waterbugs which provide energy, break down dead organic matter and support the river's food chain

System overview

The Ovens River system rises in the Great Dividing Range near Mount Hotham and flows about 150 km to join the River Murray in the backwaters of Lake Mulwala. Two small water storages have been constructed in the system: Lake Buffalo on the Buffalo River and Lake William Hovell on the King River. The regulated reaches of the Ovens River system include the Buffalo River below Lake Buffalo, the King River below Lake William Hovell and the Ovens River from its confluence with the Buffalo River to Lake Mulwala (see Figure 5.3.1).

The Ovens River system maintains relatively natural flows and has good lateral and longitudinal connectivity. This is a result of relatively small storages that spill every year and allow unregulated flows to the rivers.

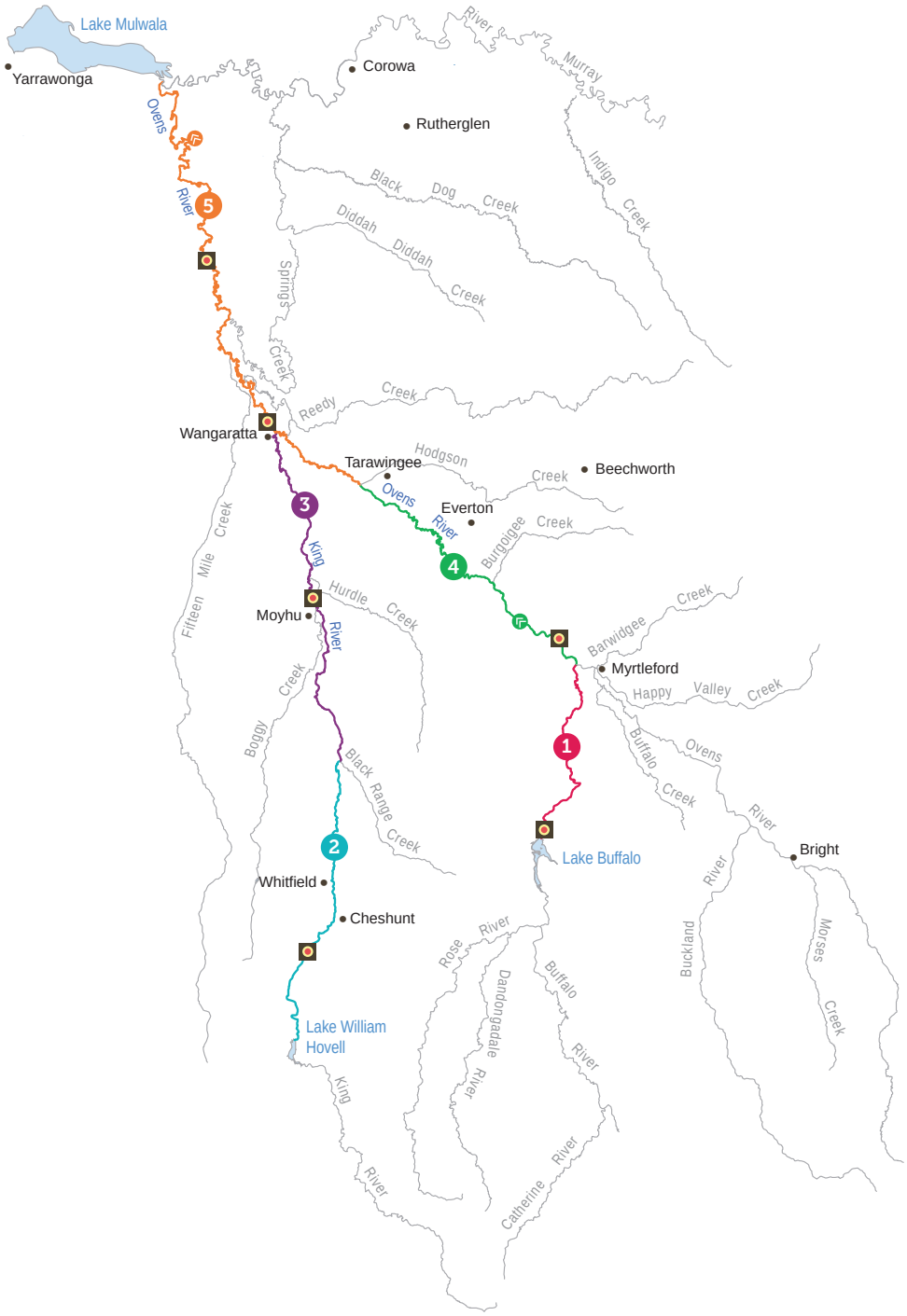
The Ovens River system contributes significantly to the water resources of the River Murray. The water that flows out of the Ovens River system is regulated by the largest weir pool (Lake Mulwala) on the Murray regulated river system. Ovens River flows contribute to the reliability and the variability of the flow regime for the River Murray and support many downstream uses (such as irrigation, urban supply and watering of iconic sites such as Barmah Forest).

Environmental water is held in Lake Buffalo and in Lake William Hovell and can be released under regulated conditions, when the storages are not spilling. There are five reaches identified in the Ovens River system that can benefit from environmental water releases. While all are important, there are relatively small environmental holdings available in the system to meet the needs of all reaches. When water is only available from the holdings, outcomes in the reaches immediately downstream of the storages are targeted. When paired with consumptive water en route, benefits are likely to be achieved downstream to the River Murray.

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

Unregulated flows occurred in the Ovens River until early spring 2014. Rainfall over spring, summer and autumn was low and consequently inflows to the storages were also very low. Releases from storage generally remained at low, stable levels during the irrigation season.

The stable, low releases from Lake William Hovell presented an opportunity to add some variability by releasing 50 ML of Commonwealth environmental water over two days in early April.

The bulk drawdown of water—a large release from Lake Buffalo to deliver consumptive use water downstream and make additional space in the storage—did not occur due to the dry conditions. Consequently, 20 ML of Commonwealth environmental water was released at the end of April to provide some variability to the releases downstream of the storage.

A key aspect of achieving managed environmental outcomes for reaches 1, 4 and 5 is the release of the bulk drawdown of water by the storage manager. Without this event, the impact of the small holdings is localised, providing some flow variability below the storages.

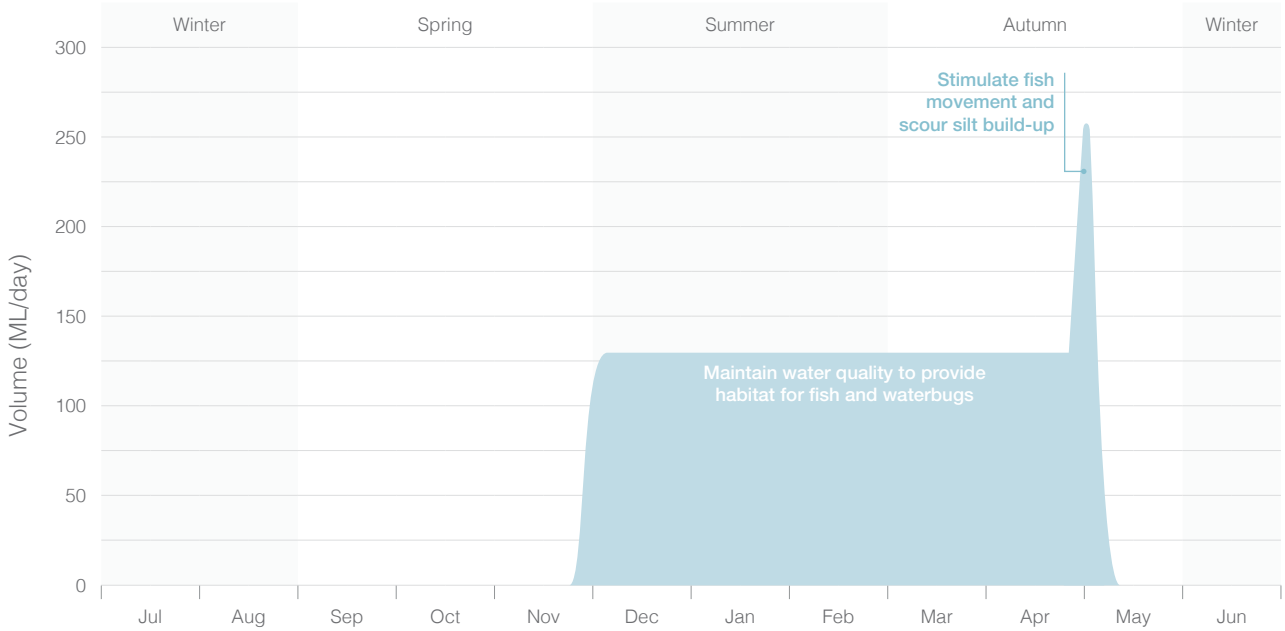
Scope of environmental watering

Potential environmental watering actions and their environmental objectives are shown in Table 5.3.1 and illustrated in Figure 5.3.2.

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 reach 5 (1 fresh of 130–260 ML/day for at least 3 days during April–May)	▸ Maintain flow cues to stimulate movement of native fish ▸ Maintain short-term fluctuations in discharge to move sediment and maintain macroinvertebrate habitat ▸ Maintain connectivity between pools and riffles ▸ Scour biofilm from river bed
Supporting summer/autumn low flows targeting reaches 1, 2 and 3 (10 ML–985 ML/day during December–May)	▸ Maintain adequate habitat for native fish ▸ Maintain natural connectivity between pools and riffles ▸ Maintain short-term fluctuations in discharge to move sediment and maintain macroinvertebrate habitat

Figure 5.3.2 Potential environmental watering in the Ovens system



Note: This figure is for illustrative purposes only. Scheduling and delivery of particular watering actions within the stated timeframes will vary.

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

Planning scenario	Dry	Average	Wet
Expected river conditions	▸ Possible winter/early spring unregulated flows ▸ Highly likely low summer/autumn flows ▸ Bulk water release unlikely	▸ High winter/spring unregulated flows ▸ Possible summer/autumn low flows ▸ Bulk water release likely	▸ High unregulated flows throughout most of the year ▸ Bulk water release likely
Expected availability of environmental water		▸ Lake William Hovell: 50 ML ▸ Lake Buffalo: 20 ML ▸ Total: 70 ML	
Potential environmental watering	▸ Summer/autumn low flows	▸ Summer/autumn low flow freshes	▸ All objectives achieved naturally ▸ Spill conditions and/or risk of overbank flows mean environmental water may not be released
Possible volume of environmental water required to meet objectives	▸ 70 ML	▸ 70 ML	▸ 0 ML

Scenario planning

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

The climatic conditions and inflow into storages have a large effect on how environmental water is likely to be used. Under dry conditions, environmental water aims to provide low-flow variability below the storages. As conditions become wetter, there are increased opportunities to piggyback environmental releases on the bulk drawdown of water from Lake Buffalo and achieve environmental outcomes for the length of the regulated river. Environmental water cannot be released if the storages are spilling and under wet conditions the additional risk of overbank flows may result in environmental water not being released at all. However, the desired flows through the Ovens system are likely to be achieved naturally under wet conditions. The Commonwealth holding in the Ovens system has a high level of security and is expected to be available under all scenarios.

Risk management

In preparing its seasonal watering proposal, North East CMA considered and assessed risks and identified mitigating strategies relating to the implementation of environmental watering. Risks and mitigating actions are continually reassessed by program partners throughout the water year (see section 1.4.4).

Engagement

The North East CMA consulted key stakeholders when preparing the seasonal watering proposal for the Ovens system. These stakeholders are shown in Table 5.3.3.

Seasonal watering proposals are informed by longer-term regional waterway strategies, environmental water management plans and environmental flow studies, which incorporate environmental, cultural, social and economic considerations.

Table 5.3.3 Key stakeholders engaged in the development of the Ovens system seasonal watering proposal

Stakeholder engagement
▸ Commonwealth Environmental Water Office ▸ Goulburn-Murray Water ▸ North East CMA Board ▸ Victorian Environmental Water Holder

5.4 Goulburn system

Waterway manager – Goulburn Broken Catchment Management Authority

Storage manager – Goulburn-Murray Water

Environmental water holders – Victorian Environmental Water Holder, Commonwealth 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, recreational and Indigenous cultural heritage values. It supports large areas of intact river red gum forest and provides habitat for threatened and endangered bird and fish species. It also contains important cultural heritage sites, provides water for Victoria's largest irrigation district and supports recreational activities such as fishing and canoeing. There are several wetlands within the Goulburn Broken catchment formally recognised for their conservation significance.

Environmental water is held and released from Lake Eildon and flows can be regulated at the Goulburn Weir.

Engagement

The Goulburn Broken CMA has consulted stakeholders when preparing the seasonal watering proposals for the Goulburn system. These stakeholders are shown in Table 5.4.1.

Seasonal watering proposals are informed by longer-term regional waterway strategies, environmental water management plans and environmental flow studies, which incorporate environmental, cultural, social and economic considerations.

Table 5.4.1 Key stakeholders engaged in the development of the Goulburn system seasonal watering proposal

Stakeholder engagement
▸ Commonwealth Environmental Water Office
▸ Goulburn-Murray Water
▸ Parks Victoria
▸ Victorian Environmental Water Holder
▸ Yorta Yorta Nation Aboriginal Corporation

5.4.1 Goulburn River

Environmental values

The Goulburn River supports a range of native fish, including golden perch, silver perch, Murray cod, trout cod, Macquarie perch and freshwater catfish. Its aquatic vegetation and submerged logs provide great diversity of habitat to support adult and juvenile fish. The bank vegetation is dominated by river red gums which provide habitat for many species including squirrel gliders. Birds such as egrets, herons and cormorants use the river to feed while frogs benefit from shallow areas.

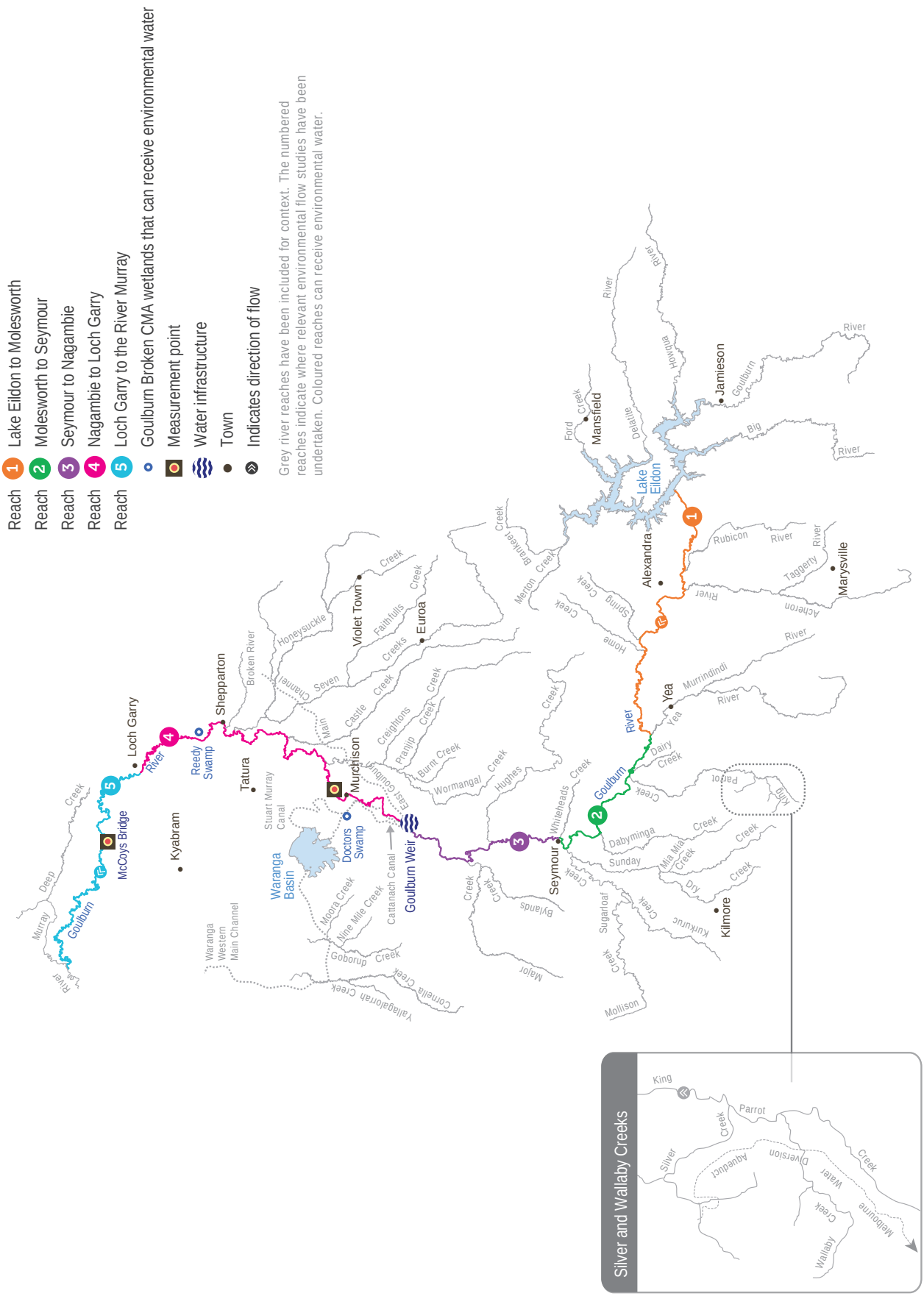
The mid-Goulburn River between Lake Eildon and Goulburn Weir is an important reach for Macquarie perch spawning, while freshwater catfish can be found in adjacent lagoons. The lower Goulburn River below Goulburn Weir is a significant source of golden perch recruitment, with monitoring showing successful spawning in response to environmental flows.

Social and economic values

The Goulburn River is popular for recreation, fishing and boating. Fishing in particular provides substantial economic and social benefits to the region, and the river supplies water for towns, stock and domestic users and irrigators. The river's floodplain also has many important Indigenous cultural heritage sites such as scar trees, mounds, stone artefact scatters and middens. The Goulburn River continues to be a place of importance for Traditional Owners and their Nations.

Environmental watering objectives in the Goulburn River	
	Increase macrophytes (large plants) and flood-tolerant plants within the river channel and lower banks, to provide shade and food for organisms further up the food chain
	Protect and boost populations of native fish (including golden perch) by providing habitat flows and encouraging fish to migrate to spawn
	Maintain the form of the river bank and channel, and a diversity of river-bed surfaces to support all stream life
	Provide habitat and nourishment for waterbugs which provide energy, break down dead organic matter and support the river's food chain

Figure 5.4.1 The Goulburn River system



Golden perch, by Jarod Lyon

System overview

Lake Eildon and Goulburn Weir have significantly modified the Goulburn River's flow pattern. Due to the impact of water harvesting, lower flows now occur in the Goulburn River in winter and spring, while higher flows occur in summer and autumn due to releases to meet irrigation and consumptive demands. This reverses what would happen naturally. The river flow regime is also affected by land use changes and by the construction of small dams and drainage schemes. Levees and other structures prevent water inundating the floodplain. Tributaries downstream of major infrastructure (such as Seven Creeks and the Broken River) help contribute natural flows to the Goulburn River in the lower reaches downstream of Goulburn Weir.

Environmental water in the Goulburn system is held by the VEWH and Commonwealth Environmental Water Holder (CEWH) and the Murray-Darling Basin Authority on behalf of the Living Murray program. The CEWH is the largest holder of environmental water in the Goulburn system. Availability and use of Commonwealth environmental water is critical to achieving outcomes in the Goulburn River. Environmental water 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.

Environmental water may need to be delivered through the Goulburn system to meet a downstream environmental demand. Where possible, these releases are managed to achieve outcomes in the Goulburn system before being reused downstream.

Environmental targets can also be met by consumptive water delivered from Lake Eildon to meet downstream demands in the River Murray (known as intervalley transfers). Goulburn intervalley transfers are expected to occur at times during the irrigation season, from spring to autumn. These flows may assist in achieving the desired environmental objectives without the need to release environmental water.

The priority reaches are reach 4 and 5 in the lower Goulburn River as they are the most flow-stressed sections of the river. Delivery of environmental flows to these target reaches also provides benefit and meets some targets in other reaches en route.

Recent conditions

Some catchment runoff occurred in winter before dry conditions commenced in spring and persisted for the rest of 2014–15. Water was released from Lake Eildon for downstream irrigation and environmental demands and remained within the river channel.

Environmental water was delivered downstream of Goulburn Weir to provide baseflows which support fish and macroinvertebrate habitat. Two spring freshes and one autumn fresh were delivered to support the recovery of amphibious bank vegetation and trigger golden perch spawning. In addition, environmental water was passed down the Goulburn River to meet environmental needs in the River Murray and other downstream locations. The delivery of consumptive (mainly irrigation) water also provided significant flows during spring, summer and early autumn. Where possible, the delivery of consumptive water was managed to support ecological outcomes.

Monitoring found successful golden perch spawning in response to environmental releases in November 2014, building on spawning that occurred in 2013. Amphibious bank vegetation is continuing its slow recovery following the Millennium Drought and subsequent flood events, with some new vegetation established below the 3,000 ML per day flow level in 2014–15.

While the delivery of freshes has been managed to reduce notching along banks, there are still anecdotal reports of erosion and slumping in the lower reaches. Monitoring will aim to determine the reasons for this bank instability.

Scope of environmental watering

Potential environmental watering actions and their environmental objectives are shown in Table 5.4.2 and illustrated in figures 5.4.2 to 5.4.4.

In addition to the watering actions, environmental water 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. This also helps prevent macroinvertebrates and fish from being stranded in small pools on river banks or benches following higher flows.

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

Potential environmental watering	Environmental objectives
Lower Goulburn River	
Year-round baseflows (500 ML/day in reach 4 and/or 540 ML/day in reach 5)	▸ Maximise habitat and movement opportunities for large- and small-bodied native fish ▸ Provide conditions that support macroinvertebrate habitat and food resources including maintaining suitable water quality, encouraging the establishment of aquatic vegetation, submerging snags and encouraging planktonic production
Spring/summer fresh (1 fresh of up to 15,000 ML/day with flows above 5,600 ML/day for 14 days in reach 4 and reach 5 during October–December)	▸ Support establishment of amphibious bank vegetation ▸ Maintain aquatic macrophyte, macroinvertebrate and fish habitat by mobilising fine sediments, submerging snags and replenishing slackwater habitat ▸ Initiate spawning and prespawning migration and support recruitment of golden perch
Winter fresh (1 fresh of up to 15,000 ML/day with flows above 6,600 ML/day for 14 days in reach 4 and reach 5 during June–August)	▸ Maintain aquatic macrophyte, macroinvertebrate and fish habitat by mobilising fine sediments, submerging snags and replenishing slackwater habitat
Summer/autumn fresh (1 fresh of up to 5,600 ML/day for 2 days in reach 4 and reach 5 during February–April)	▸ Maintain aquatic macrophyte, macroinvertebrate and fish habitat by mobilising fine sediments, submerging snags and replenishing slackwater habitat ▸ Support establishment of amphibious bank vegetation
Spring/summer fresh (1 fresh of up to 15,000 ML/day for 2 days in reach 4 and reach 5 during November–December)	▸ Initiate spawning and pre-spawning migrations and recruitment of golden perch ▸ Support establishment of amphibious bank vegetation ▸ Maintain aquatic macrophyte, macroinvertebrate and fish habitat by mobilising fine sediments, submerging snags and replenishing slackwater habitat
Increased baseflows (830 ML/day in reach 4 and/or 940 ML/day in reach 5 year-round)	▸ As for 500–540 ML/day baseflows, plus ... ▸ Submerge additional snags for macroinvertebrate food and habitat ▸ Maintain pool depths and sediment distribution ▸ Provide area of slackwater habitat in spring/summer to support spring-spawned larvae and juvenile fish
Seasonal baseflows/fresh (up to 5,000 ML/day in reach 4 and/or reach 5 year-round depending on climatic conditions)	▸ Maintain pool depth and natural rates of sediment deposition
Mid-Goulburn River	
Seasonal baseflows (400 ML/day in reach 1 and/or 800 ML/day in reach 3 year-round)	▸ Wet and maintain riffles for macroinvertebrates and small-bodied fish ▸ Maintain wetted perimeter and aquatic vegetation
Seasonal fresh (2,500–3,500 ML/day for 5–7 days in reach 1 and/or reach 3 year-round)	▸ Reduce algal build up and refresh biofilms ▸ Maintain areas of riffle habitat
Spring/summer fresh (1 fresh targeting a ~0.5m increase in river height in reach 3 for 2 days [7 day rise] from October–December)	▸ Provide flows to promote large-bodied native fish colonisation

Figure 5.4.2 Potential environmental watering in the lower Goulburn River

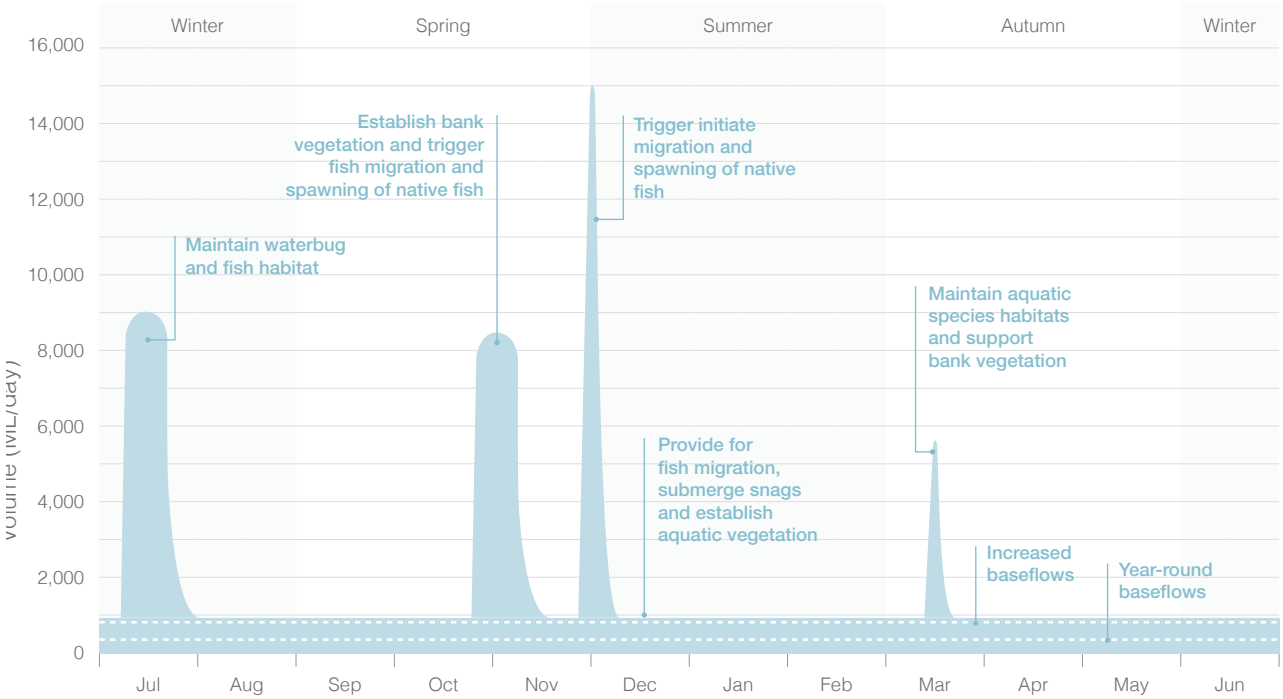
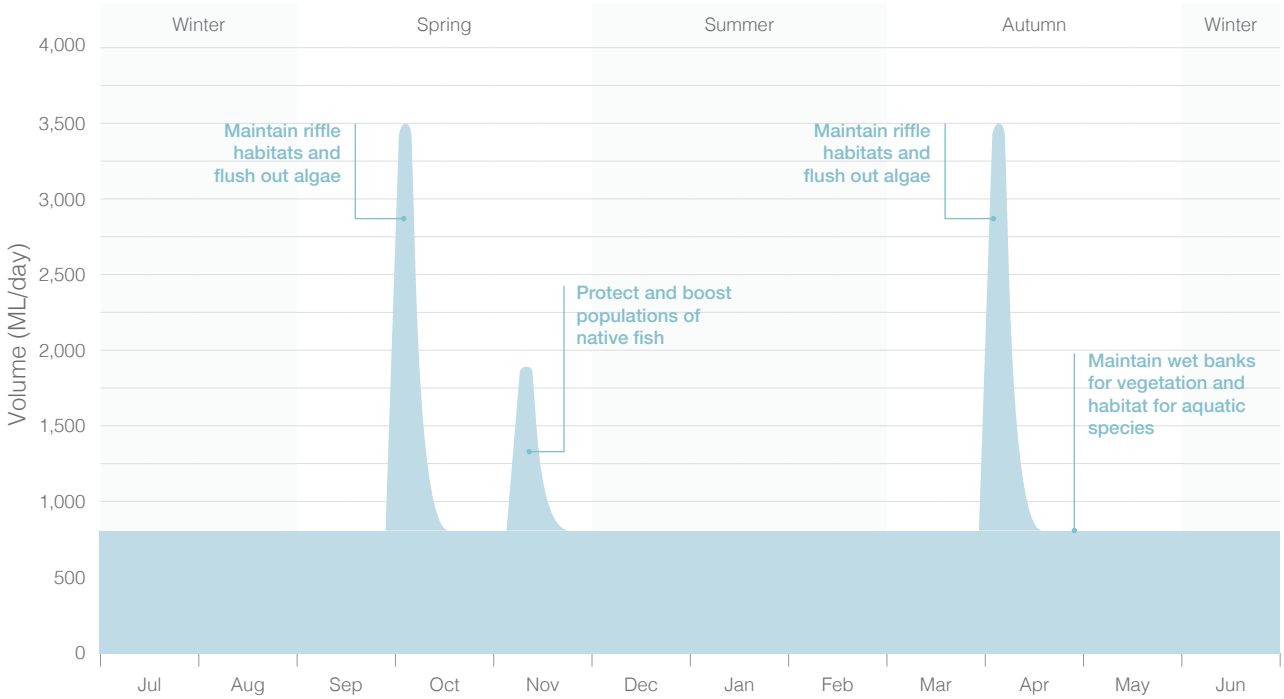


Figure 5.4.2 Potential environmental watering in the mid Goulburn River



Note: These figures are for illustrative purposes only. Scheduling and delivery of particular watering actions within the stated timeframes will vary.

Goulburn River upstream of Yambuna Outfall, by Goulburn Broken CMA

Scenario planning

Table 5.4.3 outlines the potential environmental watering and expected water usage under a range of planning scenarios.

Various triggers for action are applied as part of the adaptive management of environmental water in the Goulburn system. For example, the second spring fresh targeting golden perch spawning may not be delivered if monitoring shows spawning was achieved during the earlier, longer-duration spring fresh.

Under severe drought conditions, the highest priority for environmental watering in 2015–16 will be providing year-round baseflows, the extended duration spring fresh and the winter fresh finishing in July 2015. These provide improved habitat for animals in the river channel and support vegetation on the river banks. If better conditions occur, the additional summer/autumn fresh, shorter spring fresh and increased baseflows become achievable, targeting spawning of golden perch, macroinvertebrate and fish habitat and additional enhancement of bank vegetation.

Environmental water availability, unregulated flows and consumptive deliveries have a significant influence on the achievement of environmental watering objectives in the Goulburn system. Whilst watering actions have been proposed for the mid-Goulburn River, the primary focus will be on the achievement of lower Goulburn River objectives. Environmental water availability will be relatively high in 2015–16 and environmental watering will aim to continue to improve the overall health of the system, rather than restricting delivery to critical flows under drier scenarios.

Under wetter scenarios, unregulated flows are expected to increase, contributing to the achievement of additional objectives. As total water availability increases, the opportunity to maintain or improve the health of the river increases with the additional objectives that can be achieved. Tier-2 actions are included as desirable objectives if more water becomes available under each scenario.

In determining potential watering actions for 2015–16, consideration was given to critical carryover into 2016–17. In drought and dry scenarios, carryover is a priority to ensure baseflows can be provided from July to September 2016. If average or wet conditions occur in 2015–16, the increase in water availability for 2016–17 would mean this carryover would not be essential. If this occurs, no greater need exists in 2016–17 than 2015–16, so under these scenarios there is no targeted carryover volume for 2016–17.

Risk management

In preparing its seasonal watering proposal, Goulburn Broken CMA considered and assessed risks and identified mitigating strategies relating to the implementation of environmental watering. Risks and mitigating actions are continually reassessed by program partners throughout the water year (see section 1.4.4).

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

Planning scenario	Drought	Dry	Average	Wet
Expected river conditions	▸ No unregulated flows	▸ Unregulated flows expected to provide baseflows in winter to mid-spring and likely winter-spring freshes	▸ Unregulated flows expected to provide baseflows, several freshes and overbank flows in winter/spring	▸ Unregulated flows expected to provide high baseflows and multiple overbank flow 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 environmental water	▸ 48,000 ML VEWH ▸ 222,000 ML CEWH ▸ 20,000 ML Living Murray ▸ 290,000 ML total		▸ 48,000 ML VEWH ▸ 346,000 ML CEWH ▸ 39,000 ML Living Murray ▸ 433,000 ML total	
Potential environmental watering (tier 1)	▸ Winter 2015/spring baseflow ▸ Spring fresh ▸ Summer baseflow ▸ Autumn/winter 2016 baseflow ▸ Winter 2015 fresh ▸ Summer/autumn fresh (partial achievement) ▸ Summer increased baseflow	▸ Winter 2015/spring baseflow ▸ Spring fresh ▸ Summer baseflow ▸ Autumn/winter 2016 baseflow ▸ Winter 2015 fresh ▸ Summer/autumn fresh ▸ Spring fresh ▸ Winter 2015/spring increased baseflow ▸ Summer increased baseflow ▸ Autumn/winter 2016 increased baseflow	▸ Winter 2015/spring baseflow ▸ Spring fresh ▸ Summer baseflow ▸ Autumn/winter 2016 baseflow ▸ Winter 2015 fresh ▸ Summer/autumn fresh ▸ Spring fresh ▸ Winter 2015/spring increased baseflow ▸ Summer increased baseflow ▸ Autumn/winter 2016 increased baseflow ▸ Recession flow management	▸ Winter 2015/spring baseflow ▸ Spring fresh ▸ Summer baseflow ▸ Autumn/winter 2016 baseflow ▸ Winter 2015 fresh ▸ Summer/autumn fresh ▸ Spring fresh ▸ Winter 2015/spring increased baseflow ▸ Summer increased baseflow ▸ Autumn/winter 2016 increased baseflow ▸ Recession flow management ▸ Winter 2016 fresh
Potential environmental watering (tier 2)	▸ Summer/autumn fresh ▸ Spring fresh ▸ Winter 2015/spring increased baseflow ▸ Autumn/winter 2016 increased baseflow ▸ Recession flow management ▸ Winter 2016 fresh ▸ Spring baseflow[1] ▸ High summer baseflow ▸ Spring fresh[1] ▸ Autumn fresh[1] ▸ Spring/summer fresh[1]	▸ Recession flow management ▸ Winter 2016 fresh ▸ Spring baseflow ▸ High summer baseflow ▸ Spring fresh[1] ▸ Autumn fresh[1] ▸ Spring/summer fresh[1]	▸ Winter 2016 fresh ▸ Spring baseflow[1] ▸ High summer baseflow ▸ Spring fresh[1] ▸ Autumn fresh[1] ▸ Spring/summer fresh[1]	▸ Spring baseflow[1] ▸ High summer baseflow ▸ Spring fresh[1] ▸ Autumn fresh[1] ▸ Spring/summer fresh[1]
Possible volume of environmental water required to achieve objectives	▸ 288,000 ML (tier 1) ▸ 439,000 ML (tier 2)	▸ 432,000 ML (tier 1) ▸ 274,000 ML (tier 2)	▸ 388,000 ML (tier 1) ▸ 191,000 ML (tier 2)	▸ 433,000 ML (tier 1) ▸ 57,000 ML (tier 2)
Critical carryover into 2016–17	▸ 23,000 ML	▸ 23,000 ML	▸ 0 ML	▸ 0 ML

1 Mid-Goulburn River watering (reaches 1, 2 and/or 3)

5.4.2 Goulburn wetlands

Environmental values

There are a large number of natural wetlands across the Goulburn catchment. They include several wetlands formally recognised for their conservation significance such as Reedy Swamp, Doctors Swamp and the Corop wetlands (comprising One Tree Swamp, Two Tree Swamp, Wallenjoe Swamp and Mansfield Swamp). The wetlands contain vegetation communities ranging from swamps dominated by river red gums, and cane-grass wetlands. Reedy Swamp and Doctors Swamp receive environmental water but the Corop wetlands are not currently a priority to receive environmental water due to infrastructure limitations.

Reedy Swamp (part of the Lower Goulburn National Park and also part of the lower Goulburn River floodplain) contains a mosaic of vegetation types including tall marsh, floodway pond herbland and rushy riverine swamp. It is an important colonial nesting waterbird breeding site and drought refuge. It is also an important stopover site for migratory birds (such as sharp-tailed and marsh sandpipers).

Doctors Swamp is a bioregionally significant swamp and is considered one of the most intact red gum swamps in Victoria.

The Corop wetlands are a large hydrologically-connected system and are valued for their size, species diversity and waterbird habitat. Of note, One Tree and Two Tree swamps provide important breeding habitat for brolga and One Tree Swamp is the largest cane-grass wetland in the Goulburn Broken catchment.

Social and economic values

Visitor activities at the wetlands include bird watching, picnicking, camping and walking. Doctors Swamp is a state game reserve.

The Goulburn wetlands are identified as a culturally sensitive areas under the Victorian *Aboriginal Heritage Act 2006*. The Goulburn wetlands have been, and continue to be, places of significance for the Traditional Owners of the Yorta Yorta Nation. The area traditionally supported a rich and diverse supply of plant and animal resources for food, medicines, shelter, clothing and tools. The larger Corop catchment contains a known Aboriginal quarry where greenstone was obtained to make stone axes.

Environmental watering objectives in the Goulburn wetlands
Improve the range of native plant life, including river red gum and grassy wetland species
Provide drought refuge, habitat and breeding and feeding opportunities for migratory and colonial nesting waterbirds

Black Swamp in August 2014, by Jo Wood

System overview

Both Doctors Swamp and Reedy Swamp can receive environmental water via irrigation supply infrastructure in the Shepparton and Central Goulburn irrigation districts. The volume delivered at any one time depends on available capacity in the irrigation supply network. Reedy Swamp is naturally inundated during high flows in the Goulburn River (about 20,000 ML per day). Doctors Swamp can only receive environmental water if the Cattanach Canal is running at 2,500 ML per day and there is available capacity after irrigation demand is met, which is also influenced by the operation of Waranga Basin. Consequently, the opportunity to deliver environmental water is greater in autumn and winter.

The Corop wetlands are not currently a priority to receive environmental water due to limitations on the existing delivery infrastructure that mean the desired inundation extent cannot be achieved. In addition, the delivery of environmental water will inundate some areas of private land, which requires agreement with affected landholders. Delivery of environmental water will not occur in this system until these constraints are overcome.

Recent conditions

Delivery of environmental water to the Goulburn wetlands has not been required in recent years due to natural flooding and inflows meeting water requirements. Reedy Swamp was wet until October 2014 and naturally drew down and dried completely in December 2014. Doctors Swamp remained dry throughout 2014–15.

One Tree Swamp, Two Tree Swamp, Mansfield Swamp and Wallenjoe Swamp have been dry since February 2013 and will remain reliant on natural inflows until infrastructure works are undertaken to assist in controlling water movement in the system.

Scope of environmental watering

Potential environmental watering actions and their environmental objectives are shown in Table 5.4.4.

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

Potential environmental watering	Environmental objectives
Doctors Swamp (fill in late winter/spring 2015 or autumn 2016 and provide top-ups in spring/summer and as required)	▸ Maintain/ improve the condition of aquatic vegetation and river red gums ▸ Maintain water levels to support bird breeding
Reedy Swamp (fill in late winter/spring and provide top-ups in spring/summer as required)	▸ Maintain as a drought refuge for waterbirds ▸ Maintain/improve/promote the growth of aquatic vegetation to encourage and maintain water levels to support bird breeding

Scenario planning

Table 5.4.5 outlines potential environmental watering and expected water usage under a range of planning scenarios.

In wetter periods, the ecological and hydrological objectives of a wetland may be largely met by natural inflows and only small volumes of environmental water may be required. In drier periods when irrigation demand is high, there may be capacity constraints in the irrigation networks that may affect environmental water deliveries in the Goulburn wetlands. As such, the volume of environmental water that may be required reduces under the average and wet scenarios.

The decision to deliver environmental water to Reedy and Doctors swamps will be based on their hydrological condition and waterbird breeding activity, and the potential impact of environmental watering on wetland vegetation communities.

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

Planning scenario	Drought	Dry	Average	Wet
Expected catchment conditions	▸ No natural inflows into the wetlands	▸ Limited natural inflows into the wetlands	▸ Some catchment inflows to the wetlands	▸ Wetlands likely to fill from catchment inflows and natural flooding
Potential environmental watering	▸ Doctors Swamp ▸ Reedy Swamp			
Possible volume of environmental water required to achieve objectives	▸ Up to 3,360 ML		▸ Up to 1,680 ML	

Risk management

In preparing its seasonal watering proposal, Goulburn Broken CMA considered and assessed risks and identified mitigating strategies relating to the implementation of environmental watering. Risks and mitigating actions are continually reassessed by program partners throughout the water year (see section 1.4.4).

A male yellow billed spoonbill at Black Swamp in August 2014, by Jo Wood

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 includes the Broken River, lower Broken Creek, upper Broken Creek and wetlands. It supports threatened plant and animal species including six native fish species of state and national conservation significance and iconic species such as the Murray cod. The system also supports riparian vegetation, especially in the lower reaches of the Broken Creek. It forms an important part of the irrigation distribution system, delivering water from the Murray and Goulburn systems into the Murray Valley and Shepparton irrigation districts. It contains important Indigenous cultural heritage sites and is also popular for recreation.

Engagement

The Goulburn Broken CMA has consulted stakeholders when preparing seasonal watering proposals for the Broken system. These stakeholders are shown in Table 5.5.1.

Seasonal watering proposals are informed by longer-term regional waterway strategies, environmental water management plans and environmental flow studies, which incorporate environmental, cultural, social and economic considerations.

Table 5.5.1 Key stakeholders engaged in the development of the Broken system seasonal watering proposal

Stakeholder engagement
▸ Broken Environmental Water Advisory Group (comprising community members)
▸ Commonwealth Environmental Water Office
▸ Goulburn Broken Catchment Wetland Advisory Group (with representatives of Goulburn Valley Landcare, Field and Game Australia, Goulburn-Murray Water, Moira Shire, Council of Greater Shepparton, Turtles Australia, Parks Victoria and Tackle World)
▸ Murray-Darling Basin Authority (River Murray Water)
▸ Victorian Environmental Water Holder
▸ Yorta Yorta Nation Aboriginal Corporation

5.5.1 Upper Broken Creek

Environmental values

The upper Broken Creek area is dominated by unique box riparian vegetation and supports remnant plains grassy woodland. Much of this area also lies in the Broken–Boosey State Park, which contains high quality native vegetation. The creek supports a variety of threatened fauna, including fish species such as carp gudgeon, Murray cod, golden perch and Murray–Darling rainbowfish.

Social and economic values

Most of upper Broken Creek is in the Broken–Boosey State Park which contains a range of Indigenous cultural heritage values including scar trees and sites of significance for the Yorta Yorta and Bangerang people. The system also support a range of recreational and tourism values, providing opportunities for bushwalking, fishing and bird watching.

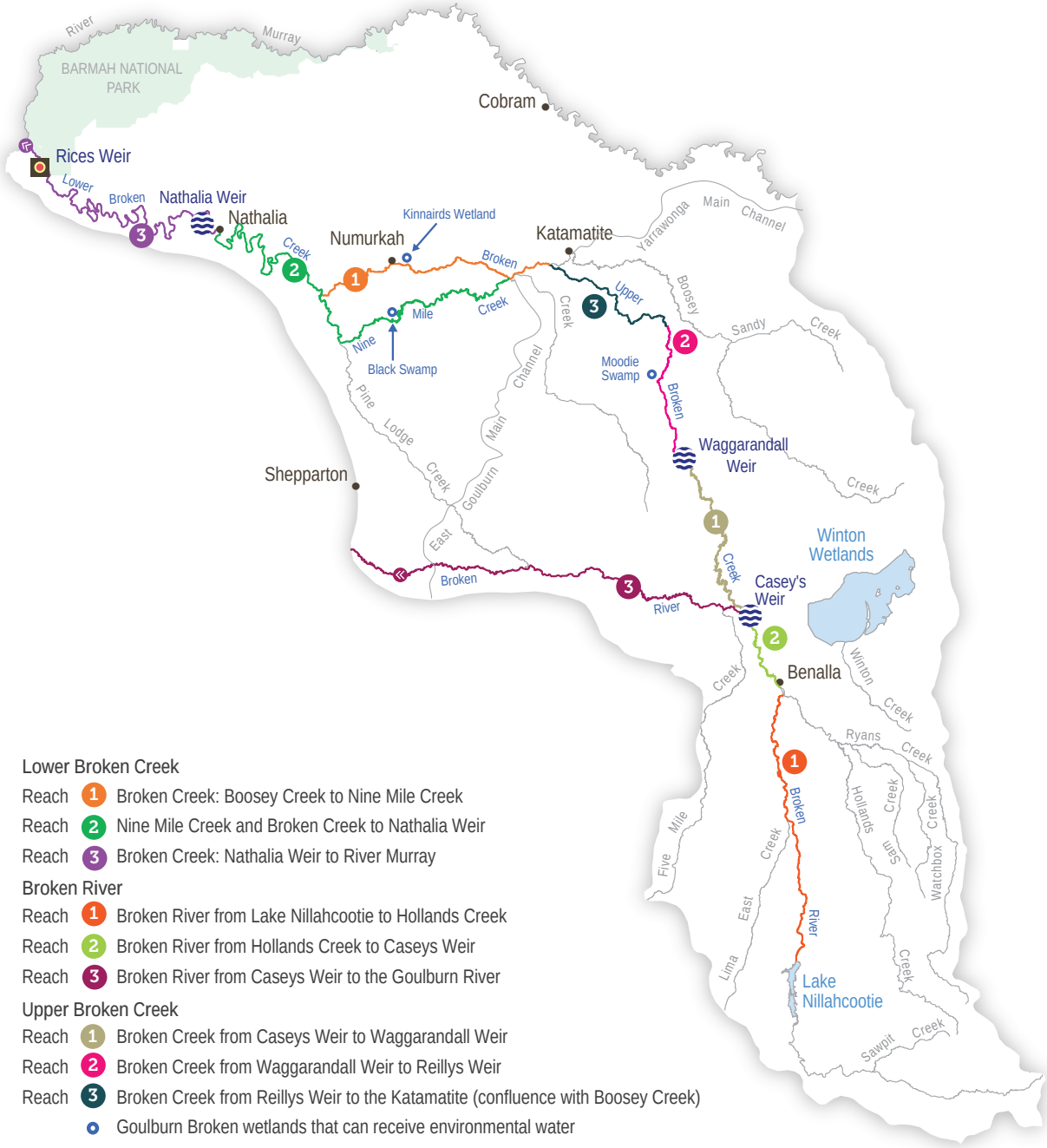
Environmental watering objectives in the upper Broken Creek system
Move built-up sand and clay material to restore deep pools and provide habitat for water animals
Improve and maintain plants on the riverbank and in the river channel
Protect and boost populations of native fish—including threatened Murray cod and golden perch—by improving pool habitat
Maintain water quality
Support a wide range of waterbugs to provide energy, break down dead organic matter and support the river's food chain

System overview

The Broken Creek diverges from the Broken River downstream of Benalla and flows to the River Murray near Barmah Forest. The creek is located on a flat riverine plain and has naturally low runoff from its local catchment. It also receives flood flows from the Broken River although these are much less frequent than occurred naturally, due to earthworks and road construction.

Upper Broken Creek is the section of creek from Casey's Weir to Katamatite that extends about 65 km. The creek has been used for water supply from the Broken River for more than 100 years although irrigation entitlements have been significantly reduced (by more than 80 percent) as part of water savings projects in the last 10 years. There are now low flows all year round at the top of the creek (from Casey's Weir to Waggarandal Weir) as water can only be supplied from Broken River based on orders from customers along the creek. In the lower reaches (from

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.

Waggarandal Weir to Reilly's Weir and from Reilly's Weir to Katamatite), the system is most influenced by rainfall and catchment runoff, which provide infrequent flow variability. Diverting water from the Broken River to the top reach achieves environmental objectives for the entire system (including the lower reaches) and allows for bankfull flows, freshes and high-flow periods.

Recent conditions

Over the last nine years, flows in the upper Broken Creek have not exceeded 70 ML per day, with minimal high-flow variability.

New rules now allow trading in the upper Broken trading zones, subject to conditions, providing some opportunity for improved environmental water availability and flow benefits. In 2014–15, 387 ML of environmental water could be transferred to upper Broken Creek from the Murray system. The water was delivered on top of irrigation demands to assist with mitigation of water quality risks following a bushfire in the region in December 2014. The fresh increased and stabilised low dissolved oxygen levels in the creek system, minimising impacts on native fish and other aquatic species in the creek.

Scope of environmental watering

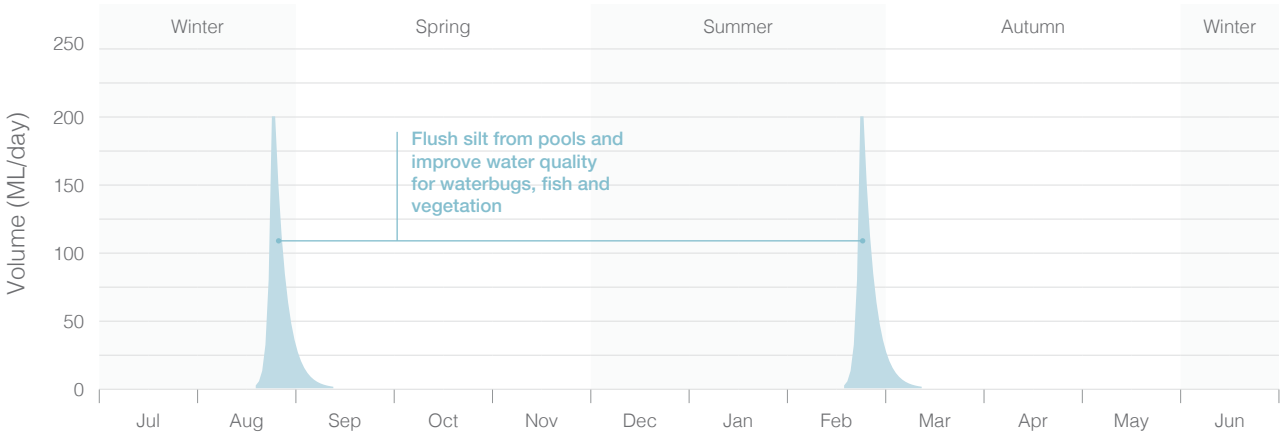
Potential environmental watering actions and their environmental objectives are shown in Table 5.5.2 and illustrated in Figure 5.5.2.

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

Potential environmental watering	Environmental objectives
Winter/spring fresh (1 fresh of up to 200 ML/day for 2 days during June–November)	▸ Rehabilitate deep-pool habitats and facilitate the movement of sediments ▸ Maintain and enhance riparian and in-channel vegetation (water ribbons and river red gum communities) with variable wet and dry zones ▸ Maintain water quality, particularly in refuge pools ▸ Maintain and restore macroinvertebrate habitats by providing intermittent freshes to complete lifecycles
Summer/autumn fresh (1 fresh of up to 200 ML/day for 2 days during December–May)	▸ Rehabilitate deep pool habitats and facilitate the movement of sediments ▸ Maintain and enhance riparian and in-channel vegetation (water ribbons and river red gum communities) with variable wet and dry zones ▸ Maintain water quality, particularly in refuge pools ▸ Maintain and restore macroinvertebrate habitats by providing intermittent freshes to complete lifecycles

Broken River, by Goulburn Broken CMA

Figure 5.5.2 Potential environmental watering in the upper Broken Creek system



Note: This figure is for illustrative purposes only. Scheduling and delivery of particular watering actions within the stated timeframes will vary.

Scenario planning

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

Use of the full 121 ML of Commonwealth environmental water available in the upper Broken Creek system is planned under all scenarios; however, this may need to be prioritised against delivery to Moodie Swamp (see section 5.5.3).

More water is required to achieve the identified potential watering actions, with an extra 280 ML required to deliver a summer/autumn fresh and more required if the winter/spring fresh is also to be delivered.

Table 5.5.3 Potential environmental watering for the upper Broken Creek system under a range of planning scenarios

Planning scenario	Drought	Dry	Average	Wet
Expected river conditions	▸ No unregulated flows	▸ Minimal unregulated flows	▸ Some contribution of unregulated flows in upper Broken Creek, particularly during winter/spring	
Expected availability of environmental water	▸ 29 ML	▸ 117 ML	▸ 121 ML	
Potential environmental watering	▸ Summer/autumn fresh			▸ Summer/autumn fresh ▸ Winter/spring fresh
Possible volume of environmental water required to achieve objectives	▸ Up to 400 ML			▸ Up to 800 ML

Risk management

In preparing its seasonal watering proposal, Goulburn Broken CMA considered and assessed risks and identified mitigating strategies relating to the implementation of environmental watering. Risks and mitigating actions are continually reassessed by program partners throughout the water year (see section 1.4.4).

5.5.2 Lower Broken Creek

Environmental values

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. The associated floodplain and wetland habitats support box-dominated grassy woodland communities and numerous threatened species of state and national conservation significance including buloke, bush stone-curlew and brolga.

Social and economic values

The lower Broken and Nine Mile creeks and associated floodplain and wetland habitats contain many important Indigenous cultural heritage sites, 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 system
Promote an increase in the cover and range of native water and riverside plants Control excessive build up of azolla, a native aquatic plant that can lower water quality in the creek when significant blooms occur
Protect and boost populations of native fish (including the threatened Murray cod, golden perch and silver perch) by providing flows for fish to move upstream and downstream, encouraging fish to spawn (release eggs)
Maintain healthy water oxygen levels

System overview

The lower Broken and Nine Mile creeks have been regulated for over 100 years, significantly altering their flow regimes. 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 (rather than from the Broken River). Under natural conditions, the creeks would have flowed in response to significant rainfall (mainly in winter and spring) and would have ceased to flow for extended periods during summer and autumn. Today, significant flows are maintained throughout summer and autumn to supply water for irrigation, domestic and stock use. From east of Nathalia downstream, the Broken Creek has eight managed shallow weirs providing a near-constant water level that facilitates the extraction of irrigation and consumptive water. While the weir pools provide important native fish habitat, their water quality is often poor in summer and autumn.

Environmental water provided in the lower Broken Creek can be sourced from both the Goulburn and Murray systems. Environmental water is released from the Goulburn system through the East Goulburn main channel and from the Murray system through the Yarrawonga main channel. The priority river reach for environmental watering is reach 3 (from Nathalia Weir Pool to the River Murray), with flows to this reach expected to also deliver the desired flows in reaches 1 and 2. The measurement point for target flows in the lower Broken Creek is at Rices Weir.

Recent conditions

Unregulated winter flows of between 100–200 ML per day in July and August 2014 were higher than in previous winters and resulted from local rainfall and catchment runoff. There were no further significant rainfall events that triggered unregulated flows in the systems for the remainder of the irrigation season.

Environmental watering commenced in late August 2014 and flows increased towards the upper target of 250 ML per day at Rices Weir in October, at which level they remained until April 2015 when cooler conditions reduced the risk of low dissolved oxygen levels. Releases dropped to 200 ML per day in April then 150 ML per day in late April before ceasing at the end of the irrigation season.

Environmental and consumptive use water were delivered primarily via the Goulburn system with some consumptive water delivered from the River Murray to bypass the Barmah choke. This helped maintain flows, resulting in the 250 ML per day target (mid-spring to mid-autumn) being met or exceeded for most of the year, and much more consistently than in previous years.

Increased levels of azolla growth occurred in spring 2014 but the flows successfully flushed them through the system, preventing a build-up. Dissolved oxygen levels fell below the target of 5 mg per litre for most of summer but did not fall below 3 mg per litre, and no impacts on native fish populations were recorded.

Scope of environmental watering

Potential environmental watering actions and their environmental objectives are shown in Table 5.5.4 and illustrated in Figure 5.5.3.

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 during August–May)	▸ Provide native fish passage
Winter/spring medium flows (120 ML/day during August–November)	▸ Minimise azolla growth
Spring/summer/autumn medium flows (150–250 ML/day during October–May)	▸ Maintain water quality, including dissolved oxygen levels above 5 mg/l
Winter/spring freshes (120–250 ML/day for up to 14 days during August–November)	▸ Remove large azolla blooms
Spring/summer high flows (250 ML/day during September–December)	▸ Increase native fish habitat during migration and breeding seasons

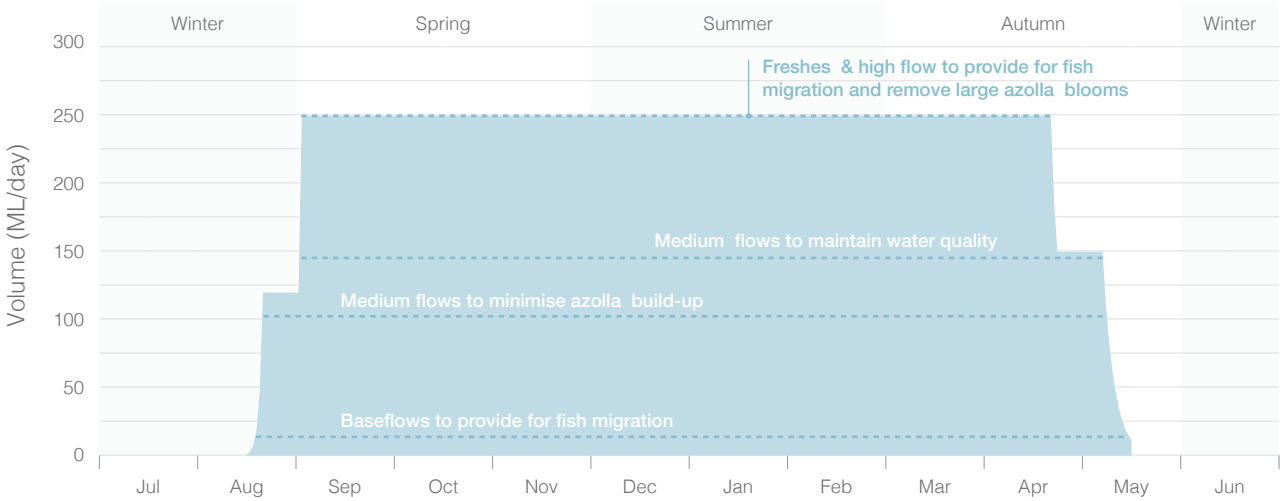
Scenario planning

Table 5.5.5 outlines the potential environmental waterings and expected water usage under a range of planning scenarios.

Due to regulation of the lower Broken and Nine Mile creeks, their environmental water needs are relatively fixed from year to year and independent of annual climatic conditions.

During the season, the environmental water flows of the lower Broken Creek can vary and focus on maximising the habitat and movement of fish, maintaining water quality and flushing azolla through the system. The required volume to meet these objectives decreases from a dry to a wet scenario as unregulated flows would contribute a greater amount under wetter conditions.

Figure 5.5.3 Potential environmental watering in the lower Broken Creek



Note: This figure is for illustrative purposes only. Scheduling and delivery of particular watering actions within the stated timeframes will vary.

Broken Creek at Wrights Bridge, by Goulburn Broken CMA

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

Planning scenario	Dry	Average	Wet
Expected river conditions	▸ Some unregulated flows during winter ▸ No unregulated flows throughout the irrigation season (mid-August–May) ▸ No diversion of unregulated River Murray flows available	▸ Unregulated flows during winter/spring ▸ No unregulated flows from October–May ▸ Diversion of unregulated River Murray flows available mid-August–October	▸ Unregulated flow during 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 medium flows ▸ Summer/autumn medium flows ▸ Winter/spring fresh ▸ Spring/summer high flows	
Possible volume of environmental water required to achieve objectives	▸ Up to 65,000 ML	▸ Up to 61,000 ML	▸ Up to 50,000 ML

Risk management

In preparing its seasonal watering proposal, Goulburn Broken CMA considered and assessed risks and identified mitigating strategies relating to the implementation of environmental watering. Risks and mitigating actions are continually reassessed by program partners throughout the water year (see section 1.4.4).

Spoonbill on Lower Broken Creek, by Keith Ward

5.5.3 Broken wetlands

Environmental values

The Broken wetlands, which include Moodie Swamp, Kinnairds wetland and Black Swamp, support a diversity of vegetation communities ranging from swamps dominated by river red gum to cane-grass wetlands. The wetlands contain several state and nationally threatened species and communities, including rigid water milfoil, slender water milfoil and river swamp wallaby-grass. The wetlands also provide food resources and breeding habitat for several bird species (such as the brolga and royal spoonbill) listed in international agreements and conventions.

Social and economic values

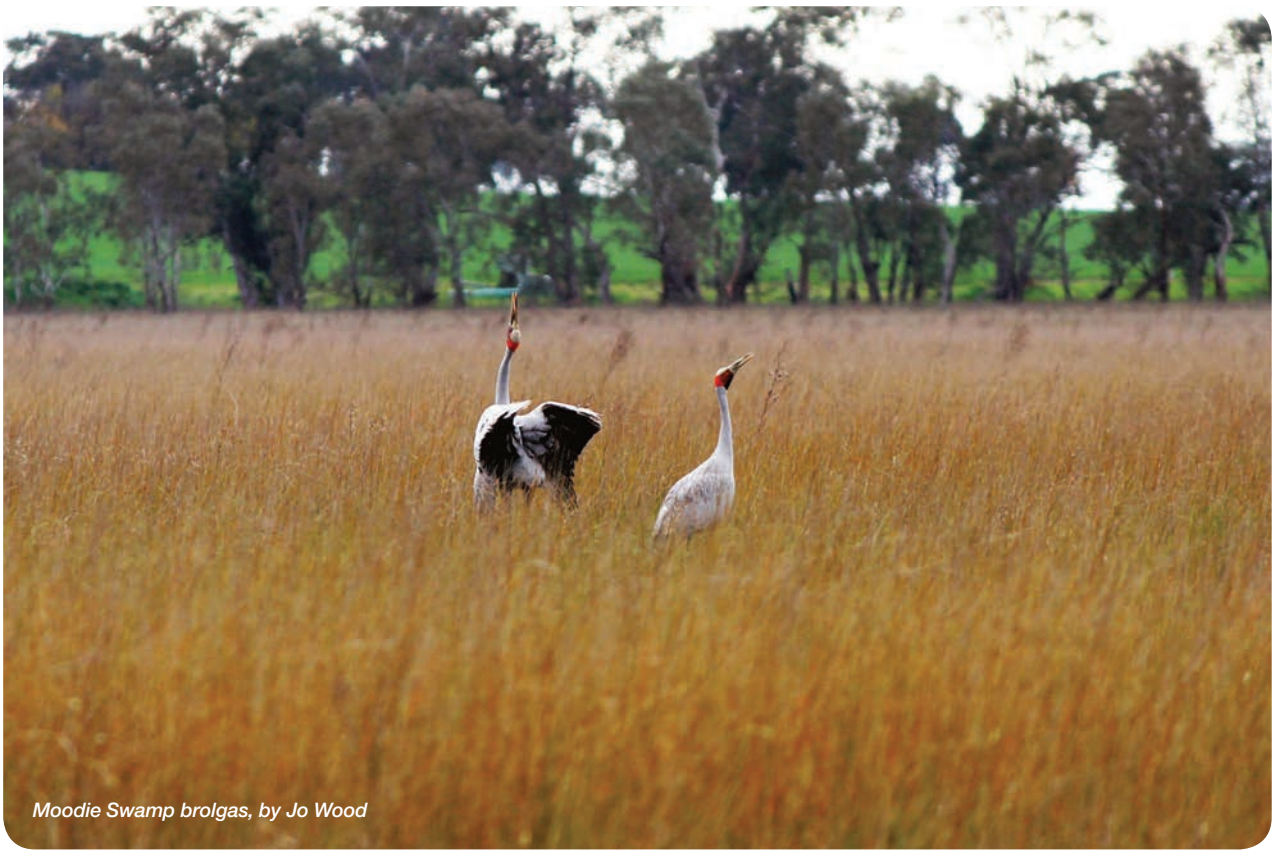
The Broken wetlands have been, and continue to be, places of significance for the Traditional Owners of the Yorta Yorta Nation. The wetlands traditionally provided a rich and diverse supply of plant and animal resources for food, medicines, shelter, clothing and tools, and some of the sites have artefacts and scar trees recorded in or adjacent to them.

The wetlands support a range of recreational activities including bird watching, bike riding, bush walking and camping. Moodie Swamp and Black Swamp are state game reserves.

Environmental watering regime objectives in the Broken wetlands
Trigger wetland vegetation recovery and growth following the 2014 fire Promote the growth of nationally threatened plant species (such as ridged water milfoil, slender water milfoil and river swamp wallaby grass)
Maintain water levels and provide vegetation to promote feeding and breeding of water birds (such as brolga)

System overview

Of some 2,000 natural wetlands in the Goulburn Broken area, only three in the Broken catchment (Black Swamp, Kinnairds wetland and Moodie Swamp) can receive environmental water. The natural water regimes of these wetlands have been greatly influenced by their positions in the surrounding Shepparton, Central Goulburn and Murray Valley irrigation districts, which have changed the timing, frequency, volume and duration of inundation. Environmental watering aims to replace some of the more natural patterns of wetting and drying of the wetlands. Water is delivered to the wetlands using irrigation supply infrastructure.



Moodie Swamp brolgas, by Jo Wood

Recent conditions

Natural flows into Kinnairds wetland and Black Swamp meant that no environmental water was needed to meet their ecological and hydrological objectives in 2014–15.

Moodie Swamp received a delivery of 500 ML in October 2014, the largest-ever environmental water delivery to the wetland. The delivery was able to support brolga breeding and encourage the growth of southern cane-grass and rigid water milfoil. Brolga were seen courting on numerous occasions and the wetland provided a food source for other wetland bird species. The Australasian bittern was also recorded calling in the wetland in September 2014.

Scope of environmental watering

Potential environmental watering actions and their environmental objectives are shown in Table 5.5.6.

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

Potential environmental watering	Environmental objectives
Moodie Swamp (fill in late winter/spring if it has remained dry and the maximum drying regime has been reached; provide top-ups as required)	▸ Promote growth of rigid water milfoil and southern cane-grass to provide habitat for Australasian bitterns and encourage brolga breeding ▸ Maintain water levels to support bird breeding for Australasian bittern and brolga if significant waterbird breeding events occur
Kinnairds wetland (fill in late winter/spring if it has remained dry and the maximum drying regime has been reached; provide top-ups as required)	▸ Promote growth of rigid water milfoil and slender water milfoil ▸ Promote wetland vegetation growth after 2014 fire, especially in seasonal herbaceous wetland areas ▸ Maintain water levels to support bird breeding for royal spoonbills and Australasian shoveler if significant waterbird breeding events occur
Black Swamp (fill in late winter/spring if it has remained dry and the maximum drying regime has been reached; provide top-ups as required)	▸ Promote/encourage growth of river swamp wallaby grass ▸ Promote wetland vegetation growth after 2014 fire ▸ Maintain water levels to support bird breeding, if significant waterbird breeding events occur

Scenario planning

Table 5.5.7 outlines the potential environmental watering and expected water usage under a range of planning scenarios.

Environmental water requirements vary according to climatic conditions. If natural inflows do not occur in the wetlands over the autumn/winter 2015 period, environmental water will be required to inundate the wetlands in winter/spring to provide conditions that promote vegetation growth and provide feeding and breeding opportunities for waterbirds.

Under drier conditions, less inflows to the wetlands mean that more environmental water will be required to achieve objectives. As catchment conditions become wetter, natural inflows to the wetlands will reduce the amount of environmental water required to be delivered to achieve the desired inundation.

Environmental water may be required to support bird breeding by maintaining stable water levels in the wetlands. The need for this action will be assessed considering the significance of the expected breeding, ecological benefits, water requirements and the potential impacts on the wetland vegetation communities.

Female scarlet robin at Moodies Swamp in April 2014, by Jo Wood

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	▸ No natural inflows into the wetlands	▸ Limited natural inflows into the wetlands	▸ Some catchment inflows to the wetlands	▸ Wetlands likely to fill from catchment inflows and natural flooding
Potential environmental watering	▸ Moodie Swamp ▸ Kinnairds wetland ▸ Black Swamp			
Possible volume of environmental water required to achieve objectives	▸ Up to 2,200 ML		▸ Up to 1,100 ML	

Risk management

In preparing its seasonal watering proposal, Goulburn Broken CMA considered and assessed risks and identified mitigating strategies relating to the implementation of environmental watering. Risks and mitigating actions are continually reassessed by program partners throughout the water year (see section 1.4.4).

Upright spotted marsh frog at Moodie Swamp, by Steve Wilson

5.6 Campaspe system

Waterway manager – North Central Catchment Management Authority

Storage manager – Goulburn-Murray Water, Coliban Water

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

The Campaspe River catchment extends from the Great Dividing Range in the south to the River Murray in the north, a total distance of about 150 km. The major waterways of the catchment are the Upper Campaspe River and the Coliban River (both upstream of Lake Eppalock) and the lower Campaspe River (downstream of Lake Eppalock). Major tributaries are McIvor and Pipers creeks upstream of Lake Eppalock, and Mount Pleasant and Axe creeks downstream of Lake Eppalock.

Malmsbury Reservoir on the Coliban River provides water for towns and stock and domestic consumption. Lake Eppalock was constructed in 1965 on the Campaspe River below the confluence with the Coliban River. It has traditionally secured water for the Campaspe Irrigation District and safeguarded the Coliban supply system for Bendigo.

Engagement

The North Central CMA has consulted stakeholders when preparing seasonal watering proposals in the Campaspe system. These stakeholders are shown in Table 5.6.1.

Seasonal watering proposals are informed by longer-term regional waterway strategies, environmental water management plans and environmental flow studies, which incorporate environmental, cultural, social and economic considerations.

Table 5.6.1 Key stakeholders engaged in the development of the Campaspe system seasonal watering proposals

Stakeholder engagement
▸ Campaspe Environmental Water Advisory Group (comprising community members, Department of Environment, Land, Water and Planning, Goulburn-Murray Water, North Central CMA, the VEWH and the Commonwealth Environmental Water Office)
▸ Coliban Water
▸ Commonwealth Environmental Water Office
▸ Goulburn-Murray Water
▸ North Central CMA Natural Resource Management Committee, an advisory group to the North Central CMA Board comprising community members
▸ Victorian Environmental Water Holder

5.6.1 Campaspe River

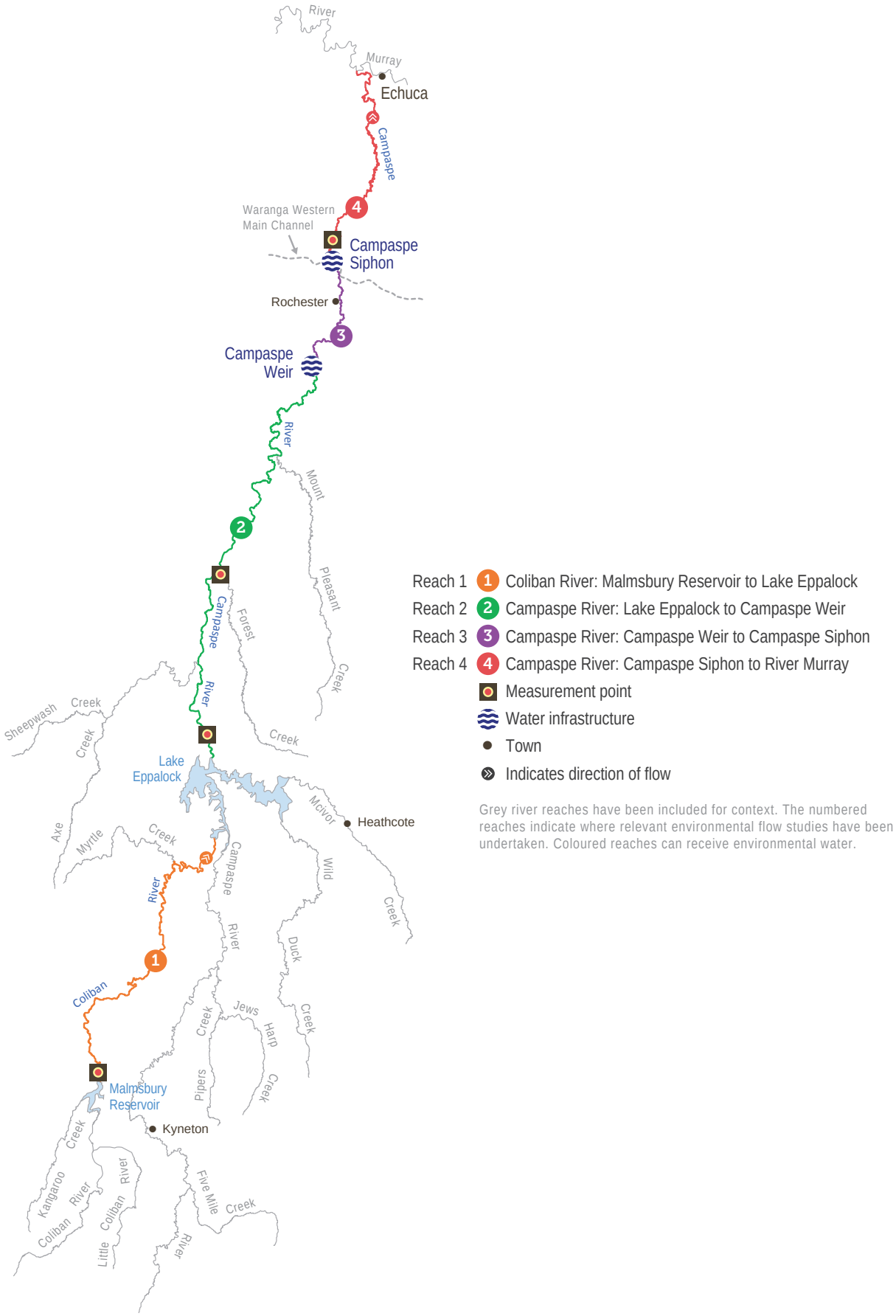
Environmental values

The Campaspe River below Lake Eppalock provides important habitat for several fish species including Murray cod, silver perch, golden perch, Murray-Darling rainbowfish and flat-headed gudgeon. Connectivity along the river and to the River Murray is an important feature to maintain migration opportunities and dispersal of juveniles. Platypuses also benefit from this connectivity and continuous flow. Turtles and frogs inhabit the river and there is a highly-connected, intact river red gum canopy along the river banks that supports terrestrial species (such as squirrel gliders).

Social, cultural and recreational values

Popular recreational activities along the Campaspe River include camping, boating, kayaking, fishing, swimming, bush walking and bird watching. These activities draw locals and tourists alike, providing economic benefit to towns along the river. The river is also valued for being an important source of water and a delivery mechanism for rural and town water. The Campaspe River is culturally significant, with Indigenous cultural heritage sites such as shell deposits, scar trees, mounds and some artefacts recorded along the banks.

Figure 5.6.1 The Campaspe system



Environmental watering objectives in the Campaspe River system
Sustain adult river red gums and encourage growth of new plants Maintain and increase the cover of in-stream and riverside plants
Provide habitat to help protect and boost populations of native fish Promote the return of native fish species (such as trout cod, river blackfish and Macquarie perch)
Support the resident platypus population by providing places to rest, breed and feed, as well as dispersal opportunities to the River Murray
Provide connection along the length of the Campaspe River and into the River Murray
Control salinity and maintain healthy levels of oxygen in deep pools
Support a wide range of waterbugs to provide energy, break down dead organic matter and support the river's food chain

System overview

The construction and operation of Lake Eppalock has significantly altered downstream river flows and reversed the seasonal flows. The storage captures rainfall runoff and reduces natural winter and spring flows downstream. Environmental water is held and released from Lake Eppalock, with some limited ability to regulate flows further downstream at the Campaspe Weir.

While the decommissioning of the Campaspe Irrigation District in 2010 significantly reduced irrigation demand in the system, consumptive water deliveries in late spring, summer and early autumn (including delivery of intervalley transfers to the Murray system) often result in higher-than-desirable flows at this time of year.

Providing the desired flows in all reaches below Lake Eppalock is important to maintain connectivity throughout the length of the Campaspe system and to the Murray River, however environmental watering usually targets reach 4, which will also achieve the desired flow objectives in reaches 2 and 3. Primary measurement points are at Barnadown (reach 2) and downstream of the Campaspe siphon (reach 4). In specific circumstances, water can be delivered to reach 4 from the Goulburn system via the Waranga western main channel.

Recent conditions

Rainfall was variable during 2014–15, with August, October and December all recording falls very much below average. While rainfall was closer-to-average in other months, streamflows for the year to the beginning of March 2015 were very low, equating to the driest three percent of years.

Delivery of winter/spring low flows continued throughout the winter 2014 period to maintain connectivity along the river and provide habitat for fish, with the target flow rate increasing to the top of the identified flow range in spring as water availability increased. Three winter/spring high-flow events were delivered during August to November, aiming to trigger fish migration, improve water quality, provide macroinvertebrate habitat and support the desired bank vegetation composition.

The delivery of consumptive water to meet downstream demands in the Murray system in late spring and summer resulted in higher-than-desirable flows, particularly in reach 2. These flows reduced the amount of slackwater habitat, which is particularly important for juvenile fish. However, some of these deliveries also supported environmental targets.

Two summer/autumn freshes were achieved in reach 4, the first in January 2015 as a result of local rainfall runoff and the second in March using consumptive water en route to water users. Consumptive water via the Waranga western main channel helped maintain 50 ML per day below the Campaspe siphon in March, before flows dropped towards the lower end of the target range in all reaches. A third summer/autumn fresh was delivered from Lake Eppalock in May, benefiting all reaches. These freshes supported in-channel and bank vegetation and improved connectivity for fish and platypuses.

Fish surveys in autumn found good numbers of Murray-Darling rainbowfish above Campaspe Weir, as well as Murray cod, turtles and platypuses. Water quality remained reasonable, with no significant low dissolved oxygen levels detected.

Scope of environmental watering

Potential environmental watering actions and their environmental objectives are shown in Table 5.6.2 and illustrated in Figure 5.6.2.

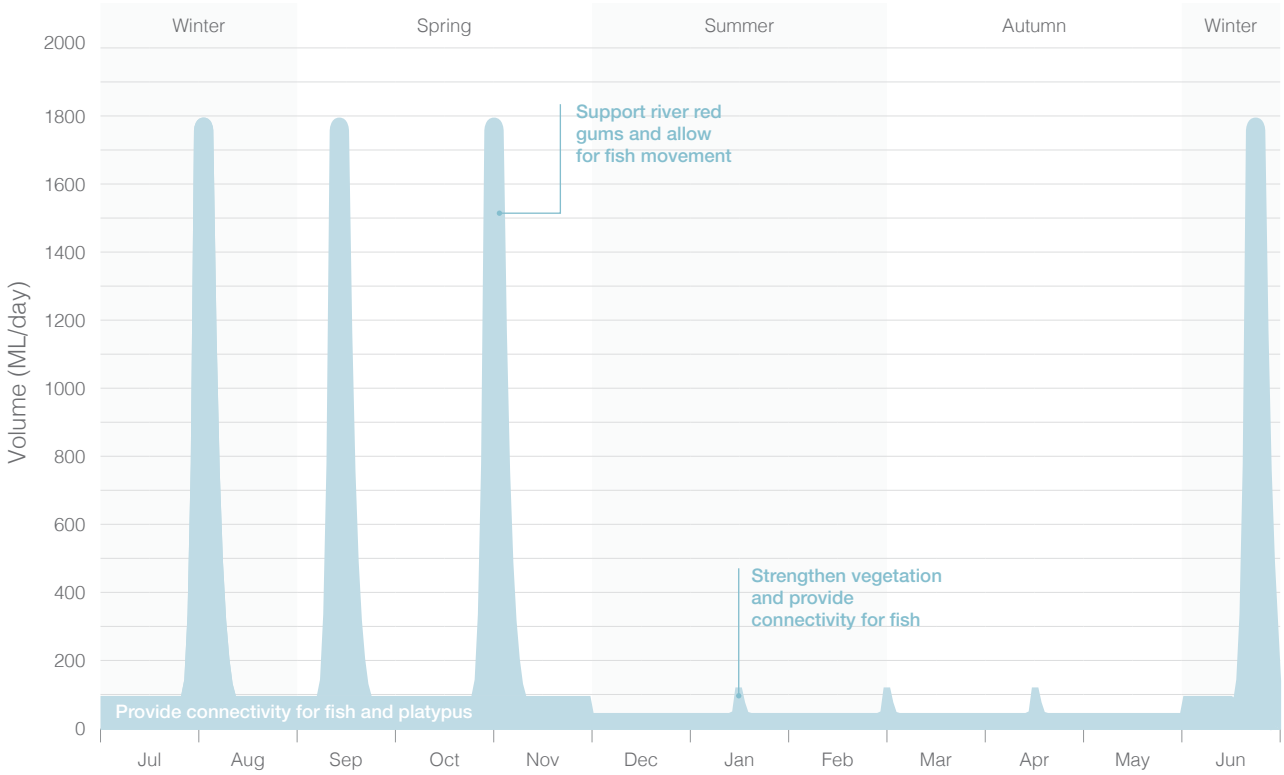
Table 5.6.2 Potential environmental watering actions and objectives for the Campaspe River system

Potential environmental watering	Environmental objectives
Summer/autumn low flows (10–50 ML/day during December–May)	▸ Maintain aquatic vegetation ▸ Maintain fish habitat and reinstate slack waters (areas with minimal water movement) ▸ Limit the effect of cold water pollution from Lake Eppalock on fish ▸ Maintain access to riffle habitat and water quality for macroinvertebrates ▸ Maintain permanent connectivity for water quality ▸ Maintain permanent connectivity for platypus movement
Winter/spring high flows (up to 4 events at 1,000–1,800 ML/day for up to 7 days each during June–November)	▸ Reduce encroachment of exotic and terrestrial vegetation ▸ Enhance river red gum recruitment ▸ Stimulate fish movement, allow movement to downstream reaches and provide spawning triggers ▸ Flush and mix river pools for water quality ▸ Flush organics from bank and benches to reduce the risk of blackwater events in summer ▸ Mix and flush river pools for macroinverbrates ▸ Inundate additional snags and flush sediment off biofilms (groups of microorganisms) for macroinvertebrates
Winter/spring low flows (50–200 ML/day [or natural[1]], during June–November)	▸ Provide longitudinal connectivity for fish ▸ Maintain access to riffle habitat and water quality for macroinvertebrates ▸ Maintain permanent longitudinal connectivity of river for improved water quality ▸ Facilitate platypus breeding opportunities
Summer/autumn freshes (up to 3 freshes of 50–200 ML/day for up to 3 days each during December–May)	▸ Maintain riparian and in-channel recruitment vegetation ▸ Increase extent of / maintain in-stream aquatic vegetation ▸ Provide longitudinal connectivity for fish during periods of low flow ▸ Maintain macroinvertebrate habitat and wash organics matter into river to drive aquatic food webs ▸ Respond to blackwater events as required

1 'Or natural' means that flow rates may be above or below the specified target rates depending on inflows and climatic conditions.

Campaspe River, by North Central CMA

Figure 5.6.2 Potential environmental watering in the Campaspe River system



Note: This figure is for illustrative purposes only. Scheduling and delivery of particular watering actions within the stated timeframes will vary.

Scenario planning

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

Potential watering actions in 2015–16 range from those considered critical under extreme drought conditions, through those aimed at recovery, to those that seek to improve the ecological health of the river under wetter conditions, making it better-placed to withstand future stress events. The potential watering actions are similar across scenarios but the target magnitude and duration of the flows increase under wetter conditions, resulting in more environmental water being required as conditions improve. Additional winter high flows will be provided under average/wet conditions.

There is no required carryover for 2016–17 but unregulated flows and consumptive use water deliveries may result in some environmental water being carried over from 2015–16. Summer low flows in 2016–17 are a high priority in the Campaspe system but can be met by a very high-reliability allocation that will be available in full on 1 July 2016. No other 2016–17 watering actions will provide greater ecological outcomes than what can be achieved in 2015–16.

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

Planning scenario	Drought	Dry	Average/Wet
Expected river conditions	▸ No unregulated flows ▸ High consumptive water deliveries in reach 2 and moderate deliveries in reaches 3 and 4 during summer	▸ Some unregulated flows in winter/spring ▸ High consumptive use water deliveries in reach 2 and moderate deliveries in reaches 3 and 4 during summer	▸ Frequent unregulated river flows particularly during winter/spring ▸ Moderate summer consumptive use water flows in all reaches
Expected availability of environmental water	▸ 10,200 ML VEWH ▸ 2,700 ML CEWH ▸ 50 ML Living Murray ▸ 6,800 ML carryover ▸ 19,750 ML total	▸ 11,300 ML VEWH ▸ 3,300 ML CEWH ▸ 75 ML Living Murray ▸ 6,800 ML carryover ▸ 21,475 ML total	▸ 20,700 ML VEWH ▸ 6,500 ML CEWH ▸ 125 ML Living Murray ▸ 0 ML carryover ▸ 27,325 ML total
Potential environmental watering	▸ Summer/autumn low flows ▸ Winter/spring high flows ▸ Winter/spring low flows ▸ Summer/autumn fresh		▸ Summer/autumn low flows ▸ Winter/spring high flows ▸ Winter/spring low flows ▸ Summer/autumn fresh ▸ Additional winter high flows
Possible volume of environmental water required to achieve objectives	▸ 15,300 ML	▸ 17,700 ML	▸ 29,100 ML

Risk management

In preparing its seasonal watering proposal, North Central CMA considered and assessed risks and identified mitigating strategies relating to the implementation of environmental watering. Risks and mitigating actions are continually reassessed by program partners throughout the water year (see section 1.4.4).

Campaspe fishway, by North Central CMA

5.6.2 Coliban River

Environmental values

The Coliban River contains a diverse range of macroinvertebrates supported by stands of emergent and submergent aquatic vegetation. It is bordered by remnant patches of stream bank shrubland vegetation providing habitat for a diverse range of terrestrial species. Historical records show that a diverse range of native freshwater fish (including Murray cod, river blackfish, Macquarie perch and Australian smelt) inhabited the river, as do populations of platypuses and native water rats.

Social and economic values

Local communities highly value the Coliban River, including Malmsbury, Taradale and Metcalfe. Of particular interest are the platypus and native water rat populations and the aesthetic and recreational values of the river (including Ellis Falls and the Cascades). Popular recreational activities in the area include camping, fishing and bird watching. The storages supply urban, stock and domestic demands in the surrounding area.

Environmental watering objectives in the Coliban system
Maintain water, riverside and in-stream plants
Protect and boost populations of native fish by providing flows for them to move upstream and downstream, encouraging spawning (release of eggs)
Improve water quality
Maintain habitat for waterbugs which provide energy, break down dead organic matter and support the river's food chain

System overview

Reach 1 of the Coliban River below Malmsbury Reservoir to Lake Eppalock can benefit from environmental watering. An important distinction between the Coliban River and other regulated Victorian systems is the lack of irrigation demand in the river, as Coliban Water deliver water from the Malmsbury Reservoir via a pipe-and-channel network. Therefore, the river below this point is not subject to the high summer flows that other regulated systems experience; delivering summer flows is reliant on environmental water releases.

The VEWH does not have any environmental entitlements in the Coliban system but the ability to flexibly manage passing flows in the system provides an opportunity to help mitigate summer low-flow risks. There is a small volume of Commonwealth environmental water held in the system but the high cost of delivery means it is not planned to be used in 2015–16.

Recent conditions

In 2014–15, conditions were dominated by below-average rainfall in most months and corresponding low volumes of inflow to the storage. The river remains in a recovery phase following the Millennium Drought, with some species (such as platypus) taking years to recover.

Passing flows were withheld in late spring/early summer to safeguard water for emergency events. These withheld flows were then used to deliver a baseflow to maintain river connectivity in the upper reaches over summer. A late-summer-autumn fresh was also delivered in March 2015 which restored connectivity with Lake Eppalock for the season.

The flows delivered were generally well below the environmental flow recommendations for the system. However, water availability in 2014–15 was limited and management aimed to balance the current needs of the river and the risk of prolonged cease-to-flow periods in summer.

Scope of environmental watering

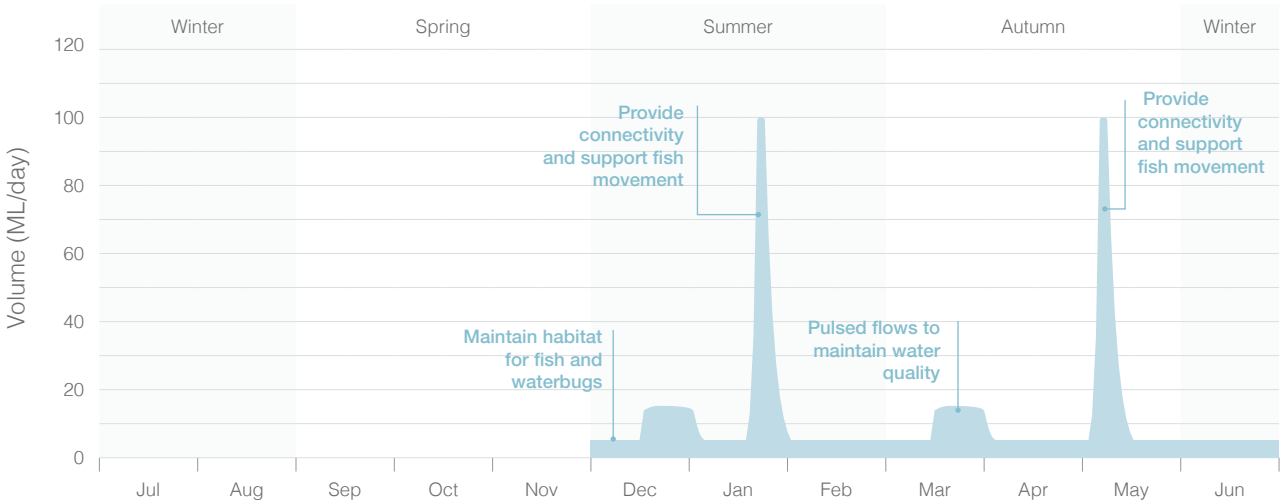
Potential environmental watering actions and their environmental objectives are shown in Table 5.6.4 and illustrated in Figure 5.6.3.

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

Potential environmental watering	Environmental objectives
Summer/autumn pulsed flows (5–15 ML/day for up to 2 weeks during December–May as required)[1]	▸ Maintain water quality (including dissolved oxygen levels) and habitat for aquatic animals
Summer/autumn low flows (2.5–5 ML/day during December–May)	▸ Maintain aquatic vegetation ▸ Maintain fish habitat for survival and spawning ▸ Maintain permanent longitudinal connectivity of river for improved water quality ▸ Maintain aquatic habitat for macroinvertebrates
Summer/autumn freshes (of 50–100 ML/day for 3 days each during December–May)	▸ Maintain riparian and in-channel recruiting vegetation ▸ Provide longitudinal connectivity for fish during periods of low flow ▸ Stimulate upstream and downstream fish movement and or spawning ▸ Maintain water quality for macroinvertebrates

1 The actual volume and duration of pulsed flows will depend on available water resources, climatic conditions and conditions within the river.

Figure 5.6.3 Potential environmental watering in the Coliban system



Note: This figure is for illustrative purposes only. Scheduling and delivery of particular watering actions within the stated timeframes will vary.

Scenario planning

Table 5.6.5 outlines the potential environmental watering and expected water usage under a range of planning scenarios.

Water availability in the Coliban system relies on withheld passing flows during winter/spring for use in the high-risk summer period, when issues such as poor water quality are more likely and providing constant low flows can maintain habitat below the reservoir. The volume of water available will vary depending on inflows and the volume of passing flows available, with a lower volume likely to be available under a dry scenario. Water is therefore not likely to be available to provide summer/autumn freshes except under average or wet conditions. The target flow and duration of freshes to manage a potentially catastrophic water quality problem will vary depending on water availability and climate and river conditions. There is insufficient water available to meet all the environmental water requirements of the Coliban system.

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

Planning scenario	Dry	Average/wet
Expected river conditions	▸ No unregulated flows	▸ Some unregulated river flows from tributary inflows
Expected availability of environmental water	▸ 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 bank flows due to possible storage spills ▸ Withheld flows for use at other times in the season
Potential environmental watering	▸ Summer/autumn pulsed flows ▸ Summer/autumn low flows	▸ Summer/autumn low flows ▸ Summer/autumn freshes
Possible volume of environmental water required to achieve objectives	▸ The volume required is highly variable based on seasonal conditions and the volume of withheld flows	

Risk management

In preparing its seasonal watering proposal, North Central CMA considered and assessed risks and identified mitigating strategies relating to the implementation of environmental watering. Risks and mitigating actions are continually reassessed by program partners throughout the water year (see section 1.4.4).

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 several native fish species and various vegetation types and supports tourism and irrigation industries. River blackfish occur in the upper catchment of the Loddon system with Birchs Creek containing a regionally significant population. Pyramid Creek is a tributary of the Loddon River, entering the system near Kerang. Along with the lower Loddon River, Pyramid Creek provides important habitat for fish (including the bony herring, golden perch and Murray cod). The Boort wetlands, located on the floodplain of the Loddon River, are important for waterbird habitat and contain high-value fringing river red gums and wetland vegetation.

Engagement

North Central CMA has engaged key stakeholders and relevant individuals in preparation of the seasonal watering proposals in the Loddon system. These stakeholders are shown in Table 5.7.1.

Seasonal watering proposals are informed by longer-term regional waterway strategies, environmental water management plans and environmental flow studies, which incorporate environmental, cultural, social and economic considerations.

Table 5.7.1 Key stakeholders engaged in the development of the Loddon system seasonal watering proposal

Stakeholder engagement
▸ Bullarook Environmental Water Advisory Group (comprising community members and representatives of Goulburn-Murray Water and the Victorian Environmental Water Holder)
▸ Goulburn-Murray Water
▸ Loddon Environmental Water Advisory Group (comprising community members and representatives of Field and Game Victoria, Department of Environment, Land, Water and Planning, Goulburn-Murray Water, North Central CMA, the Victorian Environmental Water Holder and Commonwealth Environmental Water Office)
▸ North Central CMA Natural Resource Management Committee, an advisory group to North Central CMA Board comprising community members
▸ Victorian Environmental Water Holder

5.7.1 Loddon River, Tullaroop Creek and Pyramid Creek

Environmental values

The Loddon River system upstream of Laanecoorie Reservoir contains populations of platypus, river blackfish and small native fish (such as flat-headed gudgeon, Australian smelt and mountain galaxia). River blackfish are also found in parts of Serpentine Creek with the middle and lower sections of the Loddon River having the highest fish abundance. An exciting finding in 2014–15 was the collection of River Murray rainbowfish in annual fish surveys in the lower Loddon River, which were previously not recorded in the system. Pyramid Creek supports large-bodied fish (such as golden perch) and is an important pathway for fish migration to and from the Loddon and Murray systems.

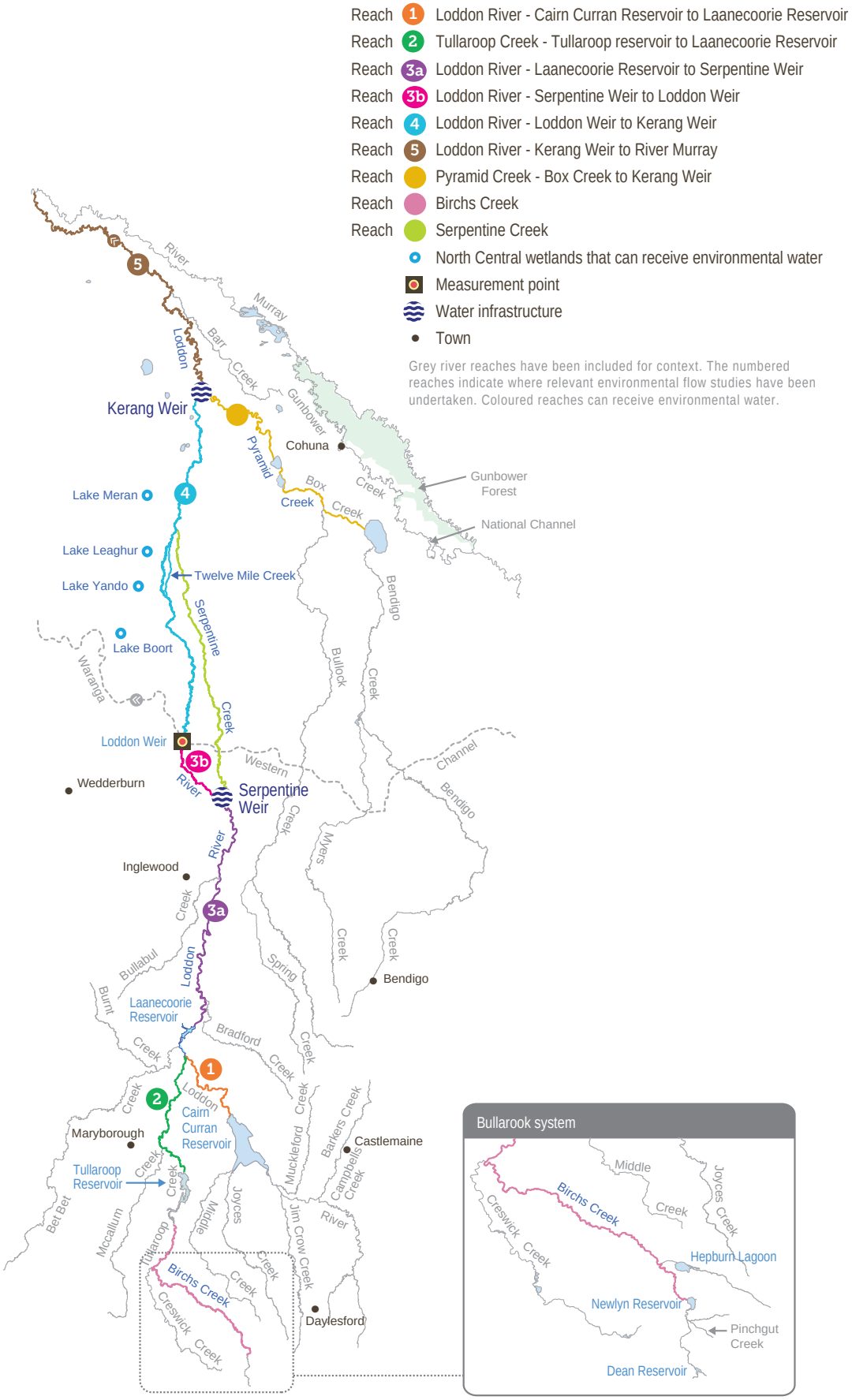
Vegetation condition is variable throughout the Loddon River system, with some reaches showing good-quality riparian and in-stream vegetation and extensive regeneration since the end of the Millennium Drought. Other reaches remain degraded and have a simplified structure, often due to the impacts of grazing, fragmentation of the riparian zone and weed invasion.

Social and economic values

Murray cod and golden perch are regularly stocked throughout the Loddon system and are an important recreational fishing species, particularly in Pyramid Creek. Bridgewater on Loddon attracts visitors to annual sporting competitions that take place on the Loddon River (such as water skiing and triathlon). The Loddon River is also rich in Aboriginal heritage with numerous heritage sites including scar trees and shell middens throughout the system.

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
	Protect and boost populations of native fish by providing flows for them to move upstream and downstream and encourage spawning (release of eggs)
	Create opportunities for young platypuses to disperse to new, high-quality habitat so they are not competing for space and food and become more resilient to threats, such as predation from foxes

Figure 5.7.1 The Loddon system



System overview

The Loddon River is Victoria's second-longest river. From its headwaters in the Great Dividing Range in central Victoria, it flows north to the River Murray (see Figure 5.7.1). The system includes the Loddon River, Tullaroop Creek, Birchs Creek and Pyramid Creek and the major storages are Cairn Curran, Tullaroop and Laanecoorie reservoirs.

Environmental water can be delivered to the Loddon River from either the Loddon or the Goulburn systems, due to the Loddon River connection with the Goulburn via the Waranga western channel. Water is also provided to Pyramid Creek and reach 5 of the Loddon River from the Murray system via the national channel.

Reach 4, between Loddon Weir and Kerang Weir, is the highest-priority reach for environmental watering because in-stream and riparian habitat has been heavily affected by river regulation. Reaches 1 (Loddon River) and 2 (Tullaroop Creek) are also a priority because they provide habitat for river blackfish and platypuses. Downstream of Kerang in reach 5 the Loddon River benefits from flows from Pyramid Creek and the upper Loddon River. Serpentine Creek is a distributary channel of the Loddon River that can receive diversions from the Loddon River at Serpentine Weir.

The complicated nature of the water distribution system in the Loddon provides both challenges and opportunities for effective environmental water delivery. When system operations permit, it is possible to manipulate the timing and location of releases to achieve environmental outcomes throughout the system. In 2014–15, the flow recommendations for the Loddon River, Serpentine Creek and Pyramid Creek were updated. As experience in managing to the new recommendations is gained in coming years, it is expected that water use efficiency and effectiveness will be improved.

Recent conditions

The Loddon system was very dry in 2014–15, particularly in summer when inflows to the Loddon storages were almost the lowest on record. Despite conditions being so dry, there was sufficient environmental water available to deliver several spring, summer and autumn freshes to improve habitat and channel form in reach 4. Environmental water also contributed to passing flows to provide low flows and maintain hydrological connectivity for the whole year.

The spring fresh delivered to reach 4 in October 2014 was carefully managed to ensure water remained in channel and did not break out and cause inconvenience to landholders. Target rates were deliberately lower than environmental flow recommendations. Monitoring of the release found that there were no impacts on private land and environmental outcomes were not compromised. North Central CMA will continue to test the delivery of freshes to this reach and liaise with landholders to maximise environmental outcomes.

In 2014–15, the construction of two fishways commenced on Pyramid Creek and the Loddon River. When completed the fishways will increase the benefit of environmental flows by providing increased migration opportunities for fish and improve the outcomes of future environmental water deliveries in the Loddon River and Pyramid Creek.

Scope of environmental watering

Potential environmental watering actions and their environmental objectives are shown in Table 5.7.2 and illustrated in figures 5.7.2 and 5.7.3.

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

Potential environmental watering	Environmental objectives
Loddon River (reach 1)	
Year-round low flows (10 to 80 ML/day year-round)[1]	▸ Allow fish movement through the reach and maintain depth of pool habitat for native fish ▸ Facilitate long-distance movement of male platypuses during the August–October breeding season ▸ Maintain suitable water quality in pools during summer
Summer/autumn freshes (up to 3 freshes of 35–80 ML/day for 1–3 days during December–May)	▸ Promote movement of fish 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 establishment, growth and survival of sedges and reeds
Winter/spring freshes (1–2 freshes of more than 400 ML/day for 1–5 days during July–October)	▸ Promote recruitment of riparian vegetation ▸ Stimulate movement of native fish and enhance Murray cod breeding ▸ Flush accumulated leaf litter from banks and low benches into the channel to drive aquatic food webs
Loddon River (reach 4)	
Summer/autumn low flow (25–50 ML/day during December–May)	▸ Continuous flow through the reach to maintain water quality in pools ▸ Maintain pool habitat for large-bodied fish (such as Murray cod, golden perch and bony herring) ▸ Maintain shallow water habitats for small-bodied fish (such as gudgeons and galaxia) ▸ Maintain a connecting flow for aquatic plant propagules to disperse and establish

Potential environmental watering	Environmental objectives
Summer/autumn freshes (up to 3 freshes 50–100 ML/day for 3–4 days during December–May)	▸ Facilitate upstream movement of juvenile golden perch ▸ Wet submerged wood and flush silt and biofilms from hard surfaces to promote new biofilm growth and increase macroinvertebrate populations ▸ Facilitate downstream dispersal of platypus in April–May
Spring high flow (one high flow of 450–750 ML/day with a 7-day peak during September–October)[2]	▸ Inundate banks, flood-runners and low-lying parts of the floodplain to promote growth and recruitment of riparian vegetation ▸ Provide a cue for golden perch and Murray cod to migrate and breed ▸ Flush leaf litter and organic material from the banks to drive aquatic food webs
Autumn high flow (1 high flow of 400 ML/day with a 6-day peak during April–May)	▸ Provide a cue for fish from the River Murray to swim upstream and colonise the Loddon River ▸ Help juvenile platypuses disperse from the upper Loddon River to the lower Loddon River and the River Murray
Winter/spring low flow (50–100 ML/day during June–November)	▸ Prevent terrestrial plants from encroaching into the channel ▸ Assist the growth of fringing vegetation (such as sedges and reeds) ▸ Provide foraging and resting habitat for platypuses
Tullaroop Creek (reach 2)	
Year-round low flows (5–40 ML/day year-round)[1]	▸ Allow fish movement through the reach and maintain the depth of pool habitat for river blackfish ▸ Facilitate long-distance movement of male platypuses during the August–October breeding season ▸ Maintain suitable water quality in pools during summer
Summer/autumn fresh (up to 3 freshes of 30–40 ML/day for 1–3 days during December–May)	▸ Promote movement of fish so they access alternate habitats ▸ Wash organic matter into the stream to drive aquatic food webs ▸ Mix and re-oxygenate pools and dilute concentrated salt ▸ Inundate lower banks to wet the soil and promote establishment, growth and survival of sedges and reeds
Winter/spring fresh (1–2 freshes of more than 200 ML/day for 1–5 days during July–October)	▸ Promote recruitment of riparian vegetation ▸ Stimulate movement of native fish and enhance Murray cod breeding ▸ Flush accumulated leaf litter from banks and low benches into the channel to drive aquatic food webs
Serpentine Creek	
Summer/autumn fresh (2 freshes of 40 ML/day for 1–3 days during December–May)	▸ Allow fish, platypuses and turtle to move through the reach ▸ Inundate benches and fringing vegetation ▸ Inundate wood and promote biofilm development ▸ Maintain water quality and prevent low dissolved oxygen conditions
Winter fresh (1 fresh of 120–150 ML/day for 1 day during July–August	▸ Flush organic material from banks to prevent risk of blackwater during summer ▸ Inundate benches and water-fringing vegetation ▸ Inundate wood and scour biofilms from the stream bed ▸ Inundate benches to provide breeding habitat for frogs
Pyramid Creek and Loddon River reach 5[3]	
Spring high flow (1 high flow 900 ML/day for 10 days during September)	▸ Trigger and facilitate fish movement
Autumn high flow (1 high flow of 900 ML/day for 10 days during March–May)	

1 Low flows in reaches 1 and 2 may need to be actively provided using environmental water, if consumptive water or passing flows are insufficient.
2 Due to potential inundation of private land, environmental flows above 450 ML per day in reach 4 will not be provided without agreement of potentially affected landholders
3 Delivery of potential watering actions to Pyramid Creek and Loddon River reach 5 are contingent on the construction of the Box Creek fishway that allows fish movement to and from Kow Swamp.

Figure 5.7.2 Potential environmental watering in the Loddon River reach 4

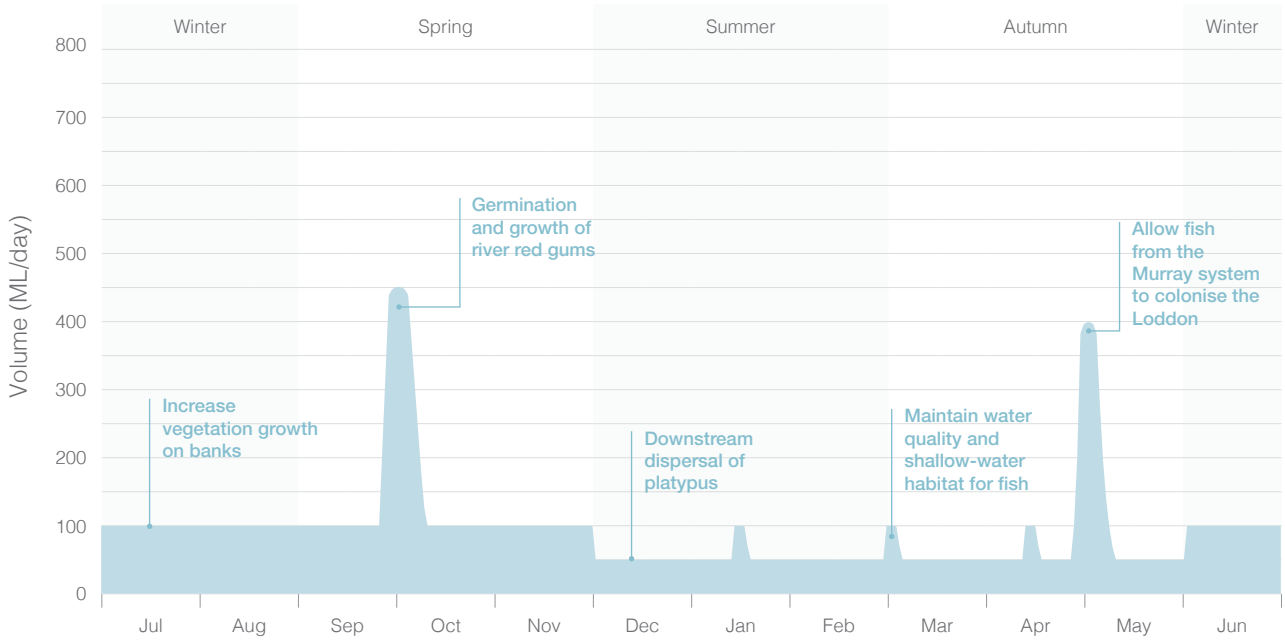
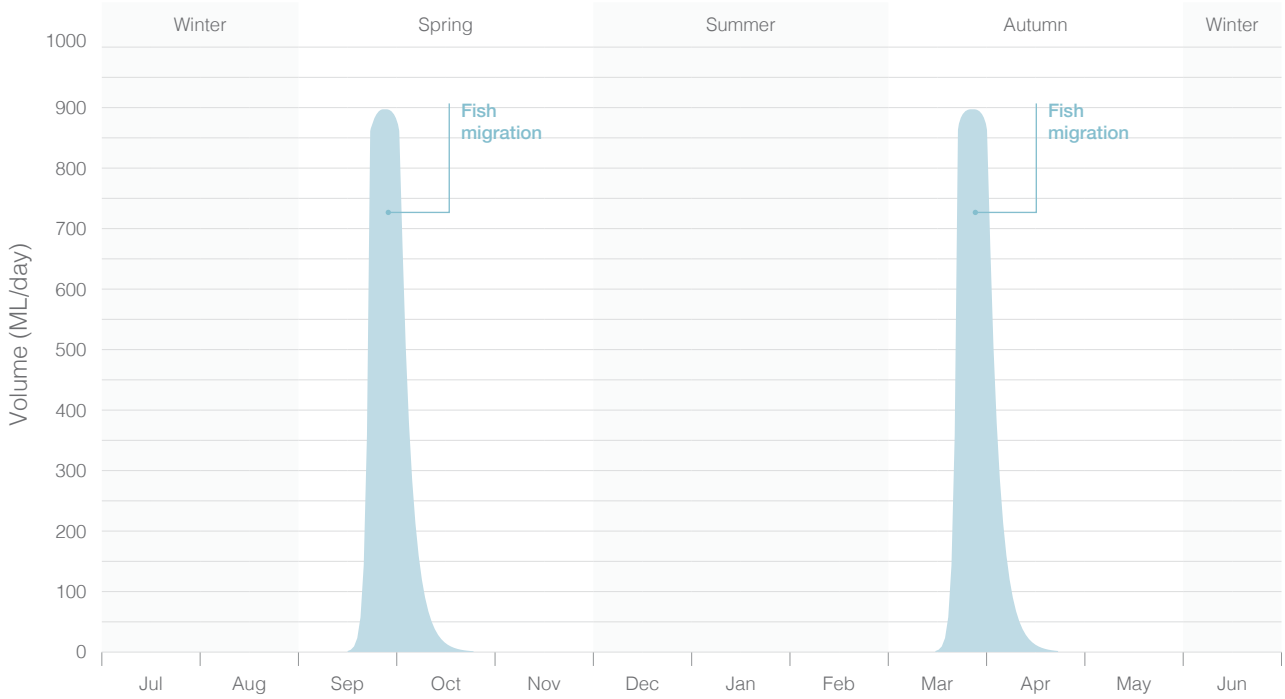


Figure 5.7.3 Potential environmental watering in the Pyramid Creek



Note: These figures are for illustrative purposes only. Scheduling and delivery of particular watering actions within the stated timeframes will vary.

Scenario planning

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

Environmental watering will be flexibly managed throughout the year depending on water availability, unregulated flows and management of consumptive water through the system.

Although a dry year occurred in 2014–15 it is expected that full allocations will be made in the Loddon system in all but the driest of outlooks for 2015–16. Passing flows that contribute substantially to low-flow requirements in the Loddon system are not expected to be restricted due to low storage volumes and therefore water made available under entitlements can mostly be used for other discretionary releases. Environmental water may be made available from the Murray system to contribute to the achievement of objectives in Pyramid Creek, as this system does not rely on delivery via the Loddon system.

Environmental water demands in the Loddon River and Serpentine Creek vary under the different scenarios. Marginally increased water availability is predicted under the average and wet scenarios and therefore the frequency of deliveries increases and extra flow components are added. The objective under these scenarios is to maximise environmental outcomes, focusing on increased fish movement and breeding. In a very wet year it is likely that many flows will be achieved naturally and therefore the possible volume of water required to meet the objectives may be lower than anticipated. If conditions remain dry, the scope of watering lessens and management will focus on protecting refuge habitat and ensuring there is water available to support important flows at the beginning of 2016–17.

Opportunities to optimise environmental water use (such as timing freshes to reach 4 to coincide with freshes from the upper Loddon system) will be explored in 2015–16. In Pyramid Creek and reach five of the Loddon River, it will be necessary to coordinate releases with consumptive water deliveries to achieve the required flow thresholds and durations.

Tullaroop Creek at Forbes Road, by Phil Slessar

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

Planning scenario	Dry	Average	Wet
Expected river conditions	▸ Small contributions from unregulated reaches and tributaries of the Loddon River contributing to low flows	▸ Unregulated flows will provide baseflows and multiple freshes, most likely during winter and spring	▸ Multiple spills from Loddon system storages will provide extended durations of high flow and overbank flow at any time of year
Expected availability of environmental water[1]	▸ 12,470–12,810 ML VEWH ▸ 2,517–3,356 ML Commonwealth ▸ 14,987–16,166 ML total	▸ 13,290 ML VEWH ▸ 3,356 ML Commonwealth ▸ 16,646 ML total	▸ 14,160 ML VEWH ▸ 3,356 ML Commonwealth ▸ 17,516 ML total
Loddon River (reach 1)			
Potential environmental watering	▸ 2 summer/autumn freshes	▸ 2 summer/autumn freshes ▸ 1 winter/spring fresh	▸ 3 summer/autumn freshes ▸ 1 winter/spring fresh
Loddon River (reach 4)			
Potential environmental watering	▸ Winter/spring high flow ▸ 2 summer/autumn freshes	▸ Winter/spring high flow ▸ 3 summer/autumn freshes ▸ 1 autumn high flow	▸ Summer/autumn low flows ▸ Winter/spring low flows ▸ Winter/spring high flow ▸ 3 summer/autumn freshes ▸ 1 autumn high flow
Tullaroop Creek (reach 2)			
Potential environmental watering	▸ 2 summer/autumn freshes	▸ 2 summer/autumn freshes ▸ 1 winter/spring fresh	▸ 3 summer/autumn freshes ▸ 1 winter/spring fresh
Serpentine Creek			
Potential environmental watering	▸ 2 summer/autumn freshes	▸ 2 summer/autumn freshes ▸ 1 winter/spring fresh	▸ 2 summer/autumn freshes ▸ 1 winter/spring fresh
Loddon River, Tullaroop Creek and Serpentine Creek			
Possible volume of environmental water required to achieve objectives	▸ 7,500 ML	▸ 14,500 ML	▸ 8,000–16,900 ML
Pyramid Creek			
Potential environmental watering	▸ None	▸ 1 spring high flow	▸ 1 spring high flow ▸ 1 autumn high flow
Possible volume of environmental water required to achieve objectives	▸ 0 ML	▸ 13,650 ML	▸ 27,300 ML

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

Risk management

In preparing its seasonal watering proposal, North Central CMA considered and assessed risks and identified mitigating strategies relating to the implementation of environmental watering. Risks and mitigating actions are continually reassessed by program partners throughout the water year (see section 1.4.4).

5.7.2 Boort wetlands

Environmental values

The Boort wetlands contain important habitat for a range of bird, reptile and amphibian species. Significant bird species that have been recorded in the Boort wetlands include the white-bellied sea eagle, Major Mitchell's cockatoo and eastern great egret. Native vegetation values include several threatened ecological vegetation types and important plant species such as cane grass and river red gum. Two rare water-dependent plants were recently found at Lake Yando, the jerry-jerry and water nymph. This discovery expands the known range of these water-dependent species much further south than was previously known.

Social, cultural and recreational values

The Boort wetlands provide recreational opportunities including for boating, camping, fishing, bird watching and hunting, and Lake Meran and Lake Boort are state game reserves. The Boort wetlands also contain important resources traditionally used by Aboriginal people and there are numerous sites that have Indigenous cultural heritage significance.

Environmental watering objectives in the Boort wetlands
Assist growth of river red gum trees (at Lake Boort) and tall marsh vegetation (at Lake Meran) and provide opportunities for aquatic plants to germinate and disperse
Restore habitat and provide breeding opportunities

System overview

The Boort wetlands are located on the floodplain to the west of the Loddon River, downstream of Loddon Weir. They include lakes Boort, Leaghur, Meran and Yando. The natural water regimes of wetlands in the Loddon system have been substantially modified. Environmental watering aims to reinstate a more natural hydrology to the wetlands (including by providing wetting and drying cycles) to improve their environmental condition and habitat value.

Recent conditions

The Loddon catchment was extremely dry in 2014–15, and the Boort wetlands did not receive any significant natural inflows. A drying phase is currently preferred for most wetlands and so the absence of inflows is not a concern right now. Lakes Meran and Yando contain water at present, whilst lakes Boort and Leaghur are dry.

Two wetlands received environmental water in 2014–15: lakes Meran and Yando. Lake Meran is a permanent wetland and was provided with a top-up—as the lake level had dropped below the desired level—to support tall marsh vegetation over summer. Lake Meran salinity levels are continuing to be monitored to inform environmental watering decisions. Lake Yando received environmental water to promote the growth of aquatic vegetation and provide opportunities for bird breeding.

Scope of environmental watering

Potential environmental watering actions and their environmental objectives are shown in Table 5.7.4.

Lake Meran, by Phil Slessar

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

Potential environmental watering	Environmental objectives
Wetland watering	
Lake Boort (partial fill in spring 2015 or autumn 2016)	▸ Restore river red gum distribution and the associated plant community including rehabilitation of southern cane grass populations ▸ Restore and rehabilitate vegetation species diversity typical of aquatic and semiaquatic environments ▸ Promote native vegetation growth to reduce the likelihood of recolonisation by mustard weed
Lake Meran (provide top-up flows in autumn 2016)	▸ Maintain emergent aquatic plant communities currently persisting at the channel outfall ▸ Restore open water/submerged aquatic plant habitat in the deeper sections of the wetland ▸ Restore tall marsh habitat across a greater area of the lake ▸ Restore habitat and breeding opportunities for waterbirds (such as pied cormorants), fish, frogs and invertebrates
Wetland drying	
Lake Leaghur and Lake Yando (promote natural drawdown and drying)	▸ These wetlands will be in a drying phase throughout 2014–15 ▸ The drying will help maintain a diversity of habitats to support a wide range of wetland-dependent birds and animals and to promote the establishment and growth of vegetation in and around the wetland

Scenario planning

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

If wet conditions eventuate, environmental water requirements are expected to be small as unregulated flows are expected to result in inundation of all wetlands. In this case, the drying regime specified for Lake Leaghur, Little Lake Meran and Lake Yando may not be achieved.

The water level at Lake Meran will be monitored throughout the year to determine if and when environmental water may be required to top up the wetland. A top-up in autumn may be provided depending on water availability, lake levels and the outcomes of an investigation into the lake's salinity response to environmental watering and irrigation diversions.

Risk management

In preparing its seasonal watering proposal, North Central CMA considered and assessed risks and identified mitigating strategies relating to the implementation of environmental watering. Risks and mitigating actions are continually reassessed by program partners throughout the water year (see section 1.4.4).

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

Planning scenario	Dry	Average	Wet
Expected catchment conditions	▸ No contribution from unregulated flows	▸ No substantial unregulated flows with localised catchment contributions expected to provide some inflows	▸ Multiple spills from Loddon system storages will provide extended durations of high flow and overbank flow at any time of year ▸ There may be an opportunity to divert flood flows into the Boort wetlands ▸ Top-ups from environmental water are unlikely to be needed
Priority watering actions	▸ Lake Boort ▸ Lake Meran		
Possible volume of environmental water required to meet objectives	▸ Up to 4,000 ML		

5.7.3 Birchs Creek

Environmental values

Birchs Creek supports several native fish species including a significant population of the regionally vulnerable river blackfish as well as mountain galaxia, flat-headed gudgeon and Australian smelt. Platypuses are present in the catchment but they are in low numbers and the population is considered to be recovering from the effects of the Millennium Drought.

Social and economic values

Birchs Creek is popular among the nearby community for its aesthetic appeal and intrinsic value.

Environmental watering regime objectives in Birchs Creek

Maintain suitable water quality to support river blackfish and other native fish

System overview

Birchs Creek in the Bullarook system is a tributary of Tullaroop Creek. There are two main storages in the system—Newlyn Reservoir and Hepburn Lagoon—which regulate stream flow for urban and irrigation supply. Environmental water is held in and delivered from Newlyn Reservoir. The target reach is reach 3 because it contains the vulnerable river blackfish population.

Recent conditions

During winter/spring 2014 rainfall in the catchment was close to average and Newlyn Reservoir spilled but a dry summer/autumn resulted in the lowest flows in the creek for several years.

The low flows and declining water quality prompted the release of an autumn fresh to Birchs Creek in April 2015, which was the first managed environmental watering in this system since May 2012. Monitoring of the flow during and following the flush demonstrated that the release was effective in lowering salinity and improving dissolved oxygen levels in the system.

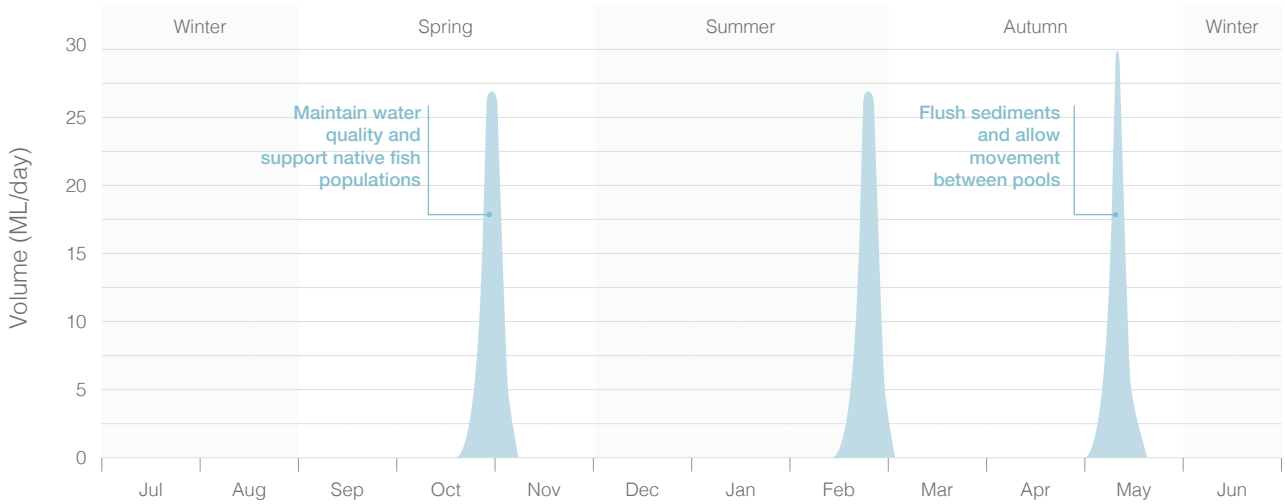
Scope of environmental watering

Potential environmental watering actions and their environmental objectives are shown in Table 5.7.6 and Figure 5.7.4.

Table 5.7.6 Potential environmental watering actions and objectives for Birchs Creek

Potential environmental watering	Environmental objectives
Two spring/summer/autumn freshes (27 ML/day for 3–4 days during November and February–March)	▸ Support native fish (including river blackfish) population structure, composition, age classes and abundance ▸ Minimise low dissolved oxygen and temperature risks for fish
Autumn pulse (30 ML/day for 1 day during March and May)	▸ Flush sediment from riffles to restore or maintain macroinvertebrate communities ▸ Allow movement between pools to maintain native fish community composition and abundance ▸ Create disturbance to rehabilitate current complexity and diversity of in-stream vegetation ▸ Rehabilitate riparian vegetation extent, structure and composition
Autumn fresh (27 ML/day for 3–4 days during March–May)	▸ Support native fish (including river blackfish) population structure, composition, age classes and abundance ▸ Flush sediment from riffles to restore or maintain macroinvertebrate communities ▸ Allow movement between pools to maintain native fish populations and abundance ▸ Create disturbance to rehabilitate the diversity of habitat, ecological diversity and physical diversity of in-stream vegetation ▸ Rehabilitate riparian vegetation extent, diversity and population structure and composition ▸ Minimise low dissolved oxygen and temperature risks for fish

Figure 5.7.4 Potential environmental watering in Birchs Creek



Note: This figure is for illustrative purposes only. Scheduling and delivery of particular watering actions within the stated timeframes will vary.

Scenario planning

Unregulated flows and passing flows provide most flows in Birchs Creek. The small volume of environmental water available in the system is reserved and called on to alleviate deteriorating water quality in summer as required, under any scenario.

Table 5.7.7 outlines the potential environmental watering and expected water usage under a range of planning scenarios.

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

Planning scenario	Dry	Average	Wet
Priority watering actions	▸ 2 spring/summer/ autumn freshes	▸ 2 spring/summer freshes ▸ 1 autumn pulse	▸ 1 autumn fresh
Possible volume of environmental water required to achieve objectives	▸ 0–100 ML	▸ 0–100 ML	▸ 0–100 ML

Risk management

In preparing its seasonal watering proposal, North Central CMA considered and assessed risks and identified mitigating strategies relating to the implementation of environmental watering. Risks and mitigating actions are continually reassessed by program partners throughout the water year (see section 1.4.4).

Birchs Creek at Nelsons Bridge, by Phil Slessar