Seasonal Watering Plan 2022-23

Section 5

VICTORIAN ENVIRONMENTAL WATER HOLDER

VICTORIA State Government

Section 5
Northern region

5.1 Northern region overview

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

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

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

Traditional Owners in the northern region

Traditional Owners and their Nations in the northern region have an intrinsic connection to Country that has endured for tens of thousands of years. This includes inherent rights and cultural obligations to Country and community.

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

There are several formal agreements in place with Traditional Owners in the northern region. In 2013, DJAARA entered into a recognition and settlement agreement under the *Traditional Owner Settlement Act 2010* in Victoria. Under the agreement, DJAARA has rights to access and use water for traditional purposes. This agreement also requires traditional ecological knowledge be incorporated into planning and policy decisions. DJAARA is continually building capacity to provide greater, more meaningful input into seasonal watering plans and to play a greater role in the administering of environmental water.

In 2004, the Victorian Government entered into a cooperative management agreement with the Yorta Yorta Nation Aboriginal Corporation to improve collaboration in the management of their Country including Barmah State Forest and reserves along the Goulburn River. In 2010, the Traditional Owner Land Management Agreement under the Conservation, Forests and Lands Act 1987 over Barmah National Park was signed, enabling the Yorta Yorta Traditional Owner Land Management Board to jointly manage Barmah National Park. In 2020, the *Barmah National Park Joint Management Plan*, prepared by the Yorta Yorta Traditional Owner Land Management Board, was publicly released. The plan guides the strategic management of Barmah National Park over the next 10 years.

In 2020, the Victorian Government and the Taungurung Land and Waters Council Aboriginal Corporation and Taungurung Traditional Owner group entered a recognition and settlement agreement (signed in 2018), under the *Traditional Owner Settlement Act 2010*.

In the context of Treaty negotiations in Victoria and the Victorian Government commitment to self-determination for First Nations, program partners in the environmental watering program are aware that structural changes to how water is managed (e.g. legislative, policy and/or governance changes) may be made in the future in recognition of Aboriginal water rights. Program partners have been hearing for many years that Traditional Owners want empowerment and agency in water management, and in many cases want to manage water on Country on their own terms.

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Engagement

Seasonal watering proposals are informed by community and program partner engagement, including Traditional Owner engagement. Program partners and communities help to identify priorities and opportunities for the delivery of water for the environment for the coming year.

Longer-term regional catchment strategies, regional waterway strategies, relevant technical studies (such as environmental flows studies), environmental water management plans and Traditional Owner Country Plans (and associated documents) also inform seasonal watering proposals. These strategies, plans and technical reports collectively describe a range of environmental, economic, social and Traditional Owner perspectives and longer-term integrated catchment and waterway management objectives that influence priorities for and the delivery of water for the environment.

The VEWH and its program partners consider cultural, social, economic and recreational values and uses of waterways when planning to deliver water for the environment. Where possible, opportunities to support these values and uses are incorporated into watering decisions, provided they do not compromise environmental outcomes. Cultural, social, economic, and recreational values considered for each system in the northern region are presented in the system sections that follow.

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

Table 5.1.1 International Association for Public Participation's Public Participation Spectrum categories and participation goals[1]

IAP2 level	Engagement goal
Inform	Provide balanced and objective information to assist understanding, alternatives, opportunities and/or solutions
Consult	Obtain feedback on analysis, alternatives and/or decisions
Involve	Work directly throughout a process to ensure that concerns and aspirations are consistently understood and considered
Collaborate	Partner in each aspect of the decision, including the development of alternatives and the identification of the preferred solution
Empower	Place final decision-making in the hands of the stakeholder

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

Tables 5.1.2 to 5.1.5 show the partners, stakeholder organisations and individuals with which each waterway manager has engaged when preparing seasonal watering proposals for the waterways under their authority. This includes engagement conducted as part of developing the seasonal watering proposals as well as engagement during the preparation of key foundational documents that directly informed the proposals. VEWH staff were also consulted for operational information as part of the development of all seasonal watering proposals by CMAs.

The tables also show the level of engagement between waterway managers and stakeholders of the environmental watering program in the northern region based on their interpretation of the IAP2 Spectrum.

The level of engagement differs between organisations and between systems, depending on the availability, capacity or interest of stakeholders to participate, roles and responsibilities of organisations in managing a site or system, and potential interaction of proposed watering with other activities on the waterway. For example, Moira Shire Council is one of two land managers for Kinnairds Wetland in the Goulburn and Broken wetlands systems, so Goulburn Broken CMA engages with them to a greater extent than it does with other local governments in areas that receive environmental flows but do not have direct responsibilities.

External factors also influence engagement opportunities. COVID-19 restrictions restricted engagement efforts across the northern region, reducing opportunities for face-to-face meetings with the community and Traditional Owners.

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Table 5.1.2 Partners and stakeholders engaged by Goulburn Broken Catchment Management Authority in developing seasonal watering proposals for the Barmah Forest, Goulburn River, Goulburn wetlands and Broken wetlands, Broken River and upper Broken Creek and lower Broken Creek systems and other key foundation documents that have directly informed the proposals (grouped in alphabetical order)

	Barmah Forest	Goulburn system	Goulburn wetlands	Broken wetlands	Broken River and upper Broken Creek	Lower Broken Creek
Community groups and environment groups	**IAP2 level: Consult** • Goulburn Broken Wetland Advisory Group members • Goulburn Murray Landcare • Goulburn Valley Environment Group • Turtles Australia	**IAP2 level: Consult** • Goulburn Valley Environment Group	**IAP2 level: Consult** • Goulburn Murray Landcare Network • Goulburn Valley Environment Group • Turtles Australia	**IAP2 level: Consult** • Goulburn Murray Landcare Network • Goulburn Valley Environment Group • Turtles Australia	**IAP2 level: Consult** • Goulburn Valley Environment Group **IAP2 level: Inform** • Broken Boosey Conservation Management Network • Broken Creek Field Naturalists Club • Goulburn Murray Landcare Network	**IAP2 level: Involve** • Goulburn Valley Environment Group **IAP2 level: Inform** • Broken Boosey Conservation Management Network • Broken Creek Field Naturalists Club • Goulburn Murray Landcare Network

	Barmah Forest	Goulburn system	Goulburn wetlands	Broken wetlands	Broken River and upper Broken Creek	Lower Broken Creek
Government agencies	**IAP2 level: Collaborate** • Commonwealth Environmental Water Office • Goulburn-Murray Water • Greater Shepparton City Council • Moira Shire Council • Murray-Darling Basin Authority • NSW Department of Planning, Industry and Environment • NSW National Parks and Wildlife Service • Parks Victoria	**IAP2 level: Collaborate** • Commonwealth Environmental Water Office • Goulburn-Murray Water • Murray-Darling Basin Authority • Parks Victoria	**IAP2 level: Collaborate** • Department of Environment, Land, Water and Planning • Goulburn-Murray Water • Greater Shepparton City Council • Moira Shire Council • Parks Victoria	**IAP2 level: Collaborate** • Department of Environment, Land, Water and Planning • Goulburn-Murray Water • Greater Shepparton City Council • Moira Shire Council • Parks Victoria	**IAP2 level: Collaborate** • Commonwealth Environmental Water Office • Goulburn-Murray Water • Parks Victoria	**IAP2 level: Collaborate** • Commonwealth Environmental Water Office • Goulburn-Murray Water • Parks Victoria
	IAP2 level: Inform • Victorian Fisheries Authority	**IAP2 level: Inform** • Victorian Fisheries Authority	**IAP2 level: Inform** • Victorian Fisheries Authority	**IAP2 level: Inform** • Victorian Fisheries Authority	**IAP2 level: Inform** • Victorian Fisheries Authority	**IAP2 level: Inform** • Moira Shire Council • Victorian Fisheries Authority
Landholders/farmers	**IAP2 level: Consult** • None in Victoria (NSW consults with Bullatale Creek landholders)	**IAP2 level: Consult** • Goulburn Environmental Water Advisory Group	**IAP2 level: Consult** • Individual landholders who are on the Goulburn Broken Wetland Management Group • Landowners that adjoin wetlands that receive water for the environment and/or use the delivery channel	**IAP2 level: Consult** • Individual landholders who are on the Goulburn Broken Wetland Management Group • Landowners that adjoin wetlands that receive water for the environment and/or use the delivery channel	**IAP2 level: Involve** • Individual landholders who are on the Broken Environmental Water Advisory Group	**IAP2 level: Involve** • Individual landholders who are on the Broken Environmental Water Advisory Group

	Barmah Forest	Goulburn system	Goulburn wetlands	Broken wetlands	Broken River and upper Broken Creek	Lower Broken Creek
Local businesses	**IAP2 level: Consult** • Trellys Fishing and Hunting	**IAP2 level: Consult** • Local ecotourism operator • Trellys Fishing and Hunting	**IAP2 level: Consult** • Trellys Fishing and Hunting	**IAP2 level: Consult** • Trellys Fishing and Hunting		
Recreational users	**IAP2 level: Consult** • Field & Game Australia		**IAP2 level: Consult** • Field & Game Australia	**IAP2 level: Consult** • Individual community members on the Broken Environmental Water Advisory Group • Field & Game Australia	**IAP2 level: Consult** • Individual community members on the Broken Environmental Water Advisory Group	**IAP2 level: Involve** • Individual community members on the Broken Environmental Water Advisory Group **IAP2 level: Inform** • Nathalia Angling Club • Numurkah Fishing Club
Technical experts		**IAP2 level: Consult** • Goulburn to Murray Trade Rule Review Scientific Advisory Panel • Scientific leads from the CEWO Monitoring, Evaluation and Research Program – Goulburn River	**IAP2 level: Consult** • Arthur Rylah Institute • Rakali Consulting • Scientists and consultants on the Goulburn Broken Wetland Technical Reference Group • Water's Edge Consulting	**IAP2 level: Consult** • Arthur Rylah Institute • Rakali Consulting • Scientists and consultants on the Goulburn Broken Wetland Technical Reference Group • Water's Edge Consulting		
Traditional Owners	**IAP2 level: Consult** • Yorta Yorta Nation Aboriginal Corporation	**IAP2 level: Consult** • Taungurung Land and Waters Council • Yorta Yorta Nation Aboriginal Corporation	**IAP2 level: Consult** • Taungurung Land and Waters Council • Yorta Yorta Nation Aboriginal Corporation	**IAP2 level: Consult** • Taungurung Land and Waters Council • Yorta Yorta Nation Aboriginal Corporation	**IAP2 level: Consult** • Taungurung Land and Waters Council • Yorta Yorta Nation Aboriginal Corporation	**IAP2 level: Involve** • Taungurung Land and Waters Council • Yorta Yorta Nation Aboriginal Corporation

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Table 5.1.3 Partners and stakeholders engaged by Mallee Catchment Management Authority in developing seasonal watering proposals for the Hattah Lakes, lower Murray wetlands and Lindsay, Mulcra and Wallpolla islands systems and other key foundation documents that have directly informed the proposals (grouped in alphabetical order)

	Hattah Lakes	Lower Murray wetlands	Lindsay, Mulcra and Wallpolla islands
Community groups and environment groups	**IAP2 level: Consult** • Mallee CMA Land and Water Advisory Committee • Mallee Conservation and Landcare Group • Mid-Murray Field Naturalists • OzFish Unlimited	**IAP2 level: Inform** • Lindsay Point Landcare Group • Millewa-Carwarp Landcare Group	**IAP2 level: Inform** • Lindsay Point Landcare Group • Millewa-Carwarp Landcare Group
		IAP2 level: Consult • OzFish Unlimited • Mallee CMA Land and Water Advisory Committee	**IAP2 level: Consult** • OzFish Unlimited • Mallee CMA Land and Water Advisory Committee
Government agencies	**IAP2 level: Collaborate** • Parks Victoria	**IAP2 level: Collaborate** • Lower Murray Water • NSW Department of Planning, Industry and Environment • Parks Victoria	**IAP2 level: Collaborate** • NSW Department of Planning, Industry and Environment • Parks Victoria
	IAP2 level: Involve • Lower Murray Water – Victorian Murray Floodplain Restoration Project Team	**IAP2 level: Involve** • Victorian Murray Floodplain Restoration Project Team	**IAP2 level: Involve** • Lower Murray Water – Victorian Murray Floodplain Restoration Project Team
	IAP2 level: Consult • Goulburn-Murray Water		**IAP2 level: Consult** • SA Water
	IAP2 level: Inform • Commonwealth Environmental Water Office • Department of Environment, Land, Water and Planning • Mildura Rural City Council • Murray-Darling Basin Authority	**IAP2 level: Inform** • Department of Environment, Land, Water and Planning • Mildura Rural City Council • Swan Hill Rural City Council	**IAP2 level: Inform** • Commonwealth Environmental Water Office • Department of Environment, Land, Water and Planning • Mildura Rural City Council • Murray-Darling Basin Authority • Victorian Fisheries Authority

	Hattah Lakes	Lower Murray wetlands	Lindsay, Mulcra and Wallpolla islands
Landholders/farmers	**IAP2 level: Inform** • Landholders and farmers who live around the Hattah Lakes	**IAP2 level: Collaborate** • Landholders and farmers who live around the lakes Powell and Carpul • Landholders and farmers who live around Robertson Creek and Wetland **IAP2 level: Inform** • Landholders and farmers who live around Heywood Lake and Little Lake Heywood • Neighbouring landholders • Landholders and farmers who live around Nyah Floodplain	**IAP2 level: Inform** • Lindsay Point irrigators • Neighbouring landholder
Local businesses	**IAP2 level: Inform** • Hattah Lakes Store • Mallee Tours • Mildura Visitor Information and Booking Centre • Murray Offroad Adventures • Victorian Apiarists' Association (Sunraysia branch) • Visit Mildura • Wildside Outdoors	**IAP2 level: Inform** • Mallee Tours • Mildura Visitor Information and Booking Centre • Murray Offroad Adventures • Victorian Apiarists' Association (Sunraysia branch) • Visit Mildura • Wildside Outdoors	**IAP2 level: Inform** • Lake Cullulleraine Store • Mallee Tours • Mildura Visitor Information and Booking Centre • Murray Offroad Adventures • Victorian Apiarists' Association (Sunraysia branch) • Visit Mildura • Wildside Outdoors
Recreational users	**IAP2 level: Inform** • BirdLife Mildura • Mildura 4WD Club • Sunraysia Bushwalkers Inc.	**IAP2 level: Inform** • BirdLife Mildura • Cabarita Community Inc. • Mildura 4WD club • Sunraysia Bushwalkers Inc.	**IAP2 level: Inform** • BirdLife Mildura • Mildura 4WD Club • Sunraysia Bushwalkers Inc.
Traditional Owners	**IAP2 level: Involve** • Traditional Owners, Elders and community members having connections with the Hattah Lakes region	**IAP2 level: Involve** • First People of the Millewa-Mallee Aboriginal Corporation • Traditional Owners, Elders and community members having connections with sites across the Murray wetlands region	**IAP2 level: Involve** • First People of the Millewa-Mallee Aboriginal Corporation • Local Aboriginal community

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Table 5.1.4 Partners and stakeholders engaged by North Central Catchment Management Authority in developing seasonal watering proposals for the Gunbower Creek and Forest, central Murray wetlands and Boort wetlands, Campaspe River, Coliban River, Loddon River, Birchs Creek and Guttrum Forest systems and other key foundation documents that have directly informed the proposals (grouped in alphabetical order)

	Gunbower Creek and Forest	Central Murray wetlands	Campaspe system	Coliban River	Loddon system (including Boort wetlands)	Birchs Creek	Guttrum Forest
Community groups and environment groups	**IAP2 level: Consult** • BirdLife Australia • Community members on the Gunbower Island Community Reference Group • Gunbower Landcare Group	**IAP2 level: Inform** • Birdlife Australia	**IAP2 level: Consult** • Ashbourne Landcare • Echuca Moama Landcare Group • Strathallan Family Landcare	**IAP2 level: Consult** • Malmsbury and District Landcare Group	**IAP2 level: Inform** • Birdlife Australia • Little Lake Boort Management Committee • Turtles Australia • Water for Wetlands		

	Gunbower Creek and Forest	Central Murray wetlands	Campaspe system	Coliban River	Loddon system (including Boort wetlands)	Birchs Creek	Guttrum Forest
Government agencies	**IAP2 level: Collaborate** • Commonwealth Environmental Water Office • Department of Environment, Land, Water and Planning • Forestry Corporation of NSW • Goulburn-Murray Water • Murray-Darling Basin Authority • Parks Victoria • VicForests	**IAP2 level: Collaborate** • Commonwealth Environmental Water Office • Department of Environment, Land, Water and Planning • Goulburn-Murray Water • Parks Victoria	**IAP2 level: Collaborate** • Commonwealth Environmental Water Office • Goulburn-Murray Water	**IAP2 level: Collaborate** • Coliban Water • Commonwealth Environmental Water Office	**IAP2 level: Collaborate** • Commonwealth Environmental Water Office • Department of Environment, Land, Water and Planning • Goulburn-Murray Water • Parks Victoria	**IAP2 level: Collaborate** • Goulburn-Murray Water	**IAP2 level: Collaborate** • Commonwealth Environmental Water Office • Department of Environment, Land, Water and Planning • Forestry Corporation of NSW • Goulburn-Murray Water • Murray-Darling Basin Authority • NSW Forests • Parks Victoria • VicForests
	IAP2 level: Inform • Campaspe Shire Council • Gannawarra Shire Council • Victorian Fisheries Authority	**IAP2 level: Inform** • Victorian Fisheries Authority	**IAP2 level: Inform** • Department of Environment, Land, Water and Planning • Game Management Authority • Victorian Fisheries Authority	**IAP2 level: Inform** • Department of Environment, Land, Water and Planning • Game Management Authority • Victorian Fisheries Authority	**IAP2 level: Inform** • Victorian Fisheries Authority	**IAP2 level: Inform** • Department of Environment, Land, Water and Planning • Parks Victoria • Victorian Fisheries Authority	**IAP2 level: Inform** • Victorian Fisheries Authority

	Gunbower Creek and Forest	Central Murray wetlands	Campaspe system	Coliban River	Loddon system (including Boort wetlands)	Birchs Creek	Guttrum Forest
Landholders/farmers	**IAP2 level: Consult** • Community members (including irrigators) on the Gunbower Island Community Reference Group	**IAP2 level: Inform** • Individual landholders and community members	**IAP2 level: Consult** • Individual landholders and community members	**IAP2 level: Inform** • Coliban Water's Rural Advisory Group • Individual landholders and community members	**IAP2 level: Inform** • Individual landholders and community members	**IAP2 level: Inform** • Individual landholders and community members	**IAP2 level: Inform** • Adjacent landholders/local community
Recreational users		**IAP2 level: Inform** • Field and Game Australia	**IAP2 level: Inform** • Local canoe club • Paddle Victoria • VRFish	**IAP2 level: Inform** • VRFish	**IAP2 level: Inform** • Field and Game • Boort Angling Club	**IAP2 level: Inform** • VRFish	
Technical experts	**IAP2 level: Collaborate** • Vegetation, fish and bird ecologists	**IAP2 level: Collaborate** • Vegetation, fish and bird ecologists	**IAP2 level: Collaborate** • Arthur Rylah Institute		**IAP2 level: Collaborate** • Arthur Rylah Institute • Vegetation, fish and bird ecologists		**IAP2 level: Collaborate** • Vegetation, fish and bird ecologists
Traditional Owners	**IAP2 level: Collaborate** • Barapa Barapa Traditional Owners **IAP2 level: Inform** • Yorta Yorta Nation Aboriginal Corporation	**IAP2 level: Collaborate** • Barapa Barapa Traditional Owners • Wamba Wemba Traditional Owners • Yorta Yorta Nation Aboriginal Corporation	**IAP2 level: Consult** • Dja Dja Wurrung Clans Aboriginal Corporation • Taungurung Land and Waters Council **IAP2 level: Inform** • Yorta Yorta Nation Aboriginal Corporation	**IAP2 level: Consult** • Dja Dja Wurrung Clans Aboriginal Corporation	**IAP2 level: Collaborate** • Barapa Barapa Traditional Owners • Dja Dja Wurrung Clans Aboriginal Corporation • Wamba Wemba Traditional Owners	**IAP2 level: Consult** • Dja Dja Wurrung Clans Aboriginal Corporation	**IAP2 level: Collaborate** • Barapa Barapa Traditional Owners • Wamba Wemba Traditional Owners

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Table 5.1.5 Partners and stakeholders engaged by North East Catchment Management Authority in developing the seasonal watering proposal for the Ovens system and other key foundation documents that have directly informed the proposal (grouped in alphabetical order)

	Ovens system
Community groups and environment groups	**IAP2 level: Collaborate** • Wangaratta Landcare and Sustainability Incorporated
Government agencies	**IAP2 level: Collaborate** • Commonwealth Environmental Water Office • Goulburn-Murray Water
	IAP2 level: Involve • Rural City of Wangaratta • Victorian Fisheries Authority
Landholders/farmers	**IAP2 level: Collaborate** • Catholic Education Department Sandhurst Diocese Limited
Technical experts	**IAP2 level: Involve** • Arthur Rylah Institute
Traditional Owners	**IAP2 level: Collaborate** • Bangerang Aboriginal Corporation • Taungurung Land and Waters Council • Yorta Yorta Nation Aboriginal Corporation

Integrated catchment management

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

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

The following are examples of complementary programs that are likely to support environmental flow outcomes in the northern region.

A strategic action plan to protect floodplain marshes in Barmah Forest is being implemented. The plan identifies management actions to address key threats to the delicate floodplain vegetation. Specific actions include removing feral horses and other invasive animals and controlling invasive plants. Parks Victoria and the Yorta Yorta Nations jointly manage Barmah National Park.

Construction of fishways at Koondrook and Cohuna weirs in Gunbower Creek was completed in winter 2021, to provide migration opportunities for species such as the iconic Murray cod. These works complement fish screens that were installed in Gunbower Creek to reduce the number of native fish lost to irrigation channels.

Restoration of Australasian bittern habitat through revegetation of tall marsh vegetation communities is continuing in Guttrum Forest. Planting will coincide with a planned delivery of water for the environment to help tall marsh become established.

Plantings of native aquatic plants in lower Broken Creek are helping accelerate the recovery of in-stream vegetation that will provide shelter and foraging habitat for native fish, platypus and other aquatic animals.

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

Risk management

During the development of the seasonal watering proposals for the northern region systems, environmental watering program partners assessed risks associated with potential environmental flows for 2022-23 and identified appropriate mitigating strategies. Risks and mitigating actions are continually assessed by program partners throughout the year (see subsection 1.3.6).

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What is the Basin Plan 2012?

Northern Victoria is a part of the Murray-Darling Basin, and deliveries of water for the environment in the northern region are subject to the requirements of the Basin Plan 2012, also known as the Murray-Darling Basin Plan or just the Basin Plan.

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

What is River Murray Increased Flows (RMIF)?

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

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

The call for and use of RMIF are coordinated by the Southern Connected Basin Environmental Watering Committee, and they must be authorised by the VEWH and NSW Department of Planning and Environment.

What is River Murray Unregulated Flows (RMUF)?

River Murray Unregulated Flows (RMUF) is the remaining unregulated water in the Murray system once Victoria and New South Wales have exercised their rights to use unregulated flows. Unregulated flow events are formally declared by the Murray-Darling Basin Authority when there is more water in the river than is needed to meet demands or can be captured in storage at the time. The use of RMUF is coordinated by the Southern Connected Basin Environmental Watering Committee for environmental outcomes.

Northern Victoria and the southern Murray-Darling Basin

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

Planning

The Basin Plan 2012 and the *Basin-wide environmental watering strategy* (second edition, 2019) guide the long-term planning of water for the environment in the Murray-Darling Basin. Under the Basin Plan, environmental objectives are met by achieving outcomes for connectivity, native vegetation, waterbirds and native fish.

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

The VEWH coordinates its activities with other environmental water holders in northern Victoria, NSW and South Australia to achieve environmental outcomes at the southern connected Murray-Darling Basin scale. Collaborative planning focuses on how upstream and downstream objectives align and how the broader operation of the Murray River system can help support environmental outcomes, as well as complementary outcomes for Traditional Owners (as set out in the 'Statement on environmental water use in 2022-23' on pages XX) and local communities.

Annual planning is documented in basin annual environmental watering priorities (by the Murray-Darling Basin Authority under the Basin Plan), in annual portfolio management plans (by the Commonwealth Environmental Water Office) and the VEWH's annual seasonal watering plan (this document). The Southern Connected Basin Environmental Watering Committee publish its annual operational scenarios for environmental flow coordination in the Murray River. In Victoria, all water for the environment must be delivered in line with the VEWH's seasonal watering plan, meaning coordination during annual planning is fundamental to successful basin-scale outcomes.

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Delivery coordination and monitoring

Environmental water holders in the Murray-Darling Basin are increasingly emphasising the coordination of water deliveries to achieve landscape-scale environmental outcomes. Examples include:

- delivering a winter fresh in the Goulburn River, which subsequently passed through to the Lower Lakes in South Australia and through the barrages to the Coorong to trigger upstream migration of fish (such as lamprey)
- delivering a spring flow from Hume Dam to support floodplain sites (such as Barmah-Millewa Forest) and the river channel from the mid-Murray to the lower Murray all the way to the Lower Lakes and Coorong in South Australia. This event carries carbon and nutrients from the floodplain to the river and transports them through the system, increasing food availability, helping native fish to move and breed and supporting native aquatic plants in the river channel.

To assess the effectiveness of landscape-scale responses to environmental flows, the Southern Connected Basin Environmental Watering Committee developed the *River Murray Channel Monitoring Plan 2021-22 to 2025-26*. The plan focuses on productivity and fish indicators to inform the management of environmental flows. This monitoring complements site-based monitoring programs across the Murray system.

Water holder partnerships and collaboration

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

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

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

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

Murray system-scale planning and Traditional Owners in the southern Murray-Darling Basin

Environmental water holders consider the objectives and cultural values of First Nations in the Murray-Darling Basin, and they seek to support these values where possible. The health of the Murray-Darling Basin benefits from meaningful partnerships with Traditional Owners, and their involvement in water planning, coordination and delivery from the local to the basin scale is a priority for environmental water holders.

In April 2021, a forum on Latji Latji Country in Mildura brought together Traditional Owner representatives from many parts of the southern Murray-Darling Basin to share information about the health of Country and discuss preferred outcomes from the management of environmental flows. Participants developed a statement on the use of water for the environment, and in April 2022, a Murray Lower Darling Rivers Indigenous Nations gathering started to refresh the statement for 2022-23.

The statement is yet to be finalised. When it is, it will be published on the VEWH website subject to approval by Traditional Owners.

The statement will be used to guide environmental flow planning for the 2022-23 water year, particularly through the Southern Connected Basin Environmental Watering Committee. The committee will work hand-in-hand with existing, site-based First Nations planning and delivery of water for the environment along the Murray. There is more information about this in the Traditional Owner cultural values and uses explanations in the following system sections.

Seasonal outlook 2022-23

Rainfall across most of northern Victoria in 2021-22 was close to or above the long-term average, and it was much greater than average in the north-east, especially in the upper Murray catchment. Mean maximum temperatures were average in the east and above average in the west of the region.

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Wet conditions through winter/spring caused Hume Dam to spill on multiple occasions and delivered frequent, small-to-medium-sized, unregulated flow events in the Murray River. Most Victorian tributaries (such as the Goulburn River) had small, unregulated flow events in winter/spring, although the Campaspe River downstream of Lake Eppalock largely missed out. The Murrumbidgee and lower Darling rivers in New South Wales were also wetter than usual, and they contributed significant flow to the Murray system. The combination of unregulated flows downstream of Hume Dam and inflows from Victorian and New South Wales tributaries created the largest and most sustained high flow in the Murray River since 2016, especially downstream of the Murray–Murrumbidgee junction. Water for the environment was delivered to rivers and wetlands across the region to help achieve watering actions needed to support native plants and animals under average to wet climate scenarios.

Due to prolonged, unregulated flows in the Murray River, very few inter-valley transfers (IVTs) were delivered from the Goulburn system during summer and autumn in 2021-22. This resulted in lower flows during the hotter months (which is a more natural situation), and it allowed some recovery of bank vegetation that has been damaged by high IVT flows in recent years. Ongoing limits on the delivery of IVTs to protect the environment are needed for the recovery of bank vegetation and protection of the banks to continue. The Victorian Government is reviewing and developing the Goulburn to Murray trade and operating rules to deliver IVTs while protecting the environment.

The climate outlook for June to August 2022 indicates there is a greater than 80 probability of exceeding median rainfall, while temperatures are more likely to be at or below the median. Above-median rainfall in responsive catchments during winter is likely to result in unregulated flow events in some systems. Environmental flows to rivers and floodplains may be delivered before, during or after unregulated flows to improve environmental outcomes.

The allocation outlook for 2022-23 provided by the Northern Victoria Resource Manager on 16 May 2022 indicated opening allocations at or above 52 percent for high-reliability water shares in the Murray, Goulburn/Loddon and Campaspe systems, and the manager predicted reaching 100 percent by mid-October under average to wet scenarios. The smaller Broken and Bullarook systems have less water in reserve, and they are more reliant on catchment conditions during winter/spring 2022 for increases. While carried-over water is less important than in recent years due to greater opening allocations in the larger systems, it is still needed to ensure sufficient early-season water is available to meet winter and early-spring demands. There is a relatively high risk of carryover being lost to spill in 2022-23, especially in the Victorian Murray system.

The high water availability forecast for 2022-23 means critical actions, including some larger floodplain watering events, can occur regardless of the climatic conditions. While some Murray floodplains received water in 2021-22, some parts of the floodplain have not been inundated since 2016-17. The permanent and semi-permanent wetlands of Gunbower Forest and the lakes within Hattah have received water for the environment in recent years, but the remainder of the floodplain has missed out. Gunbower Forest floodplain watering is planned to commence in June 2022 and continue into 2022-23, while water levels in the Hattah Lakes may be topped-up to target vegetation communities slightly higher on the floodplain. The higher parts of Barmah Forest that have remained dry in recent years are above current operational flow constraints, and they can only be watered by large, unregulated flow events.

The number of wetlands across northern Victoria likely to receive water for the environment in 2022-23 will depend on climatic conditions. More wetlands will be watered under average and wet scenarios to respond to ecological cues in the landscape (for example, waterbird breeding). Wetlands that are not likely to exceed their dry tolerance interval may not receive water under dry or drought scenarios. Some wetlands will be deliberately allowed to draw down and dry to support important dry-phase ecological processes unless they are inundated by a natural flood. High water availability means planned actions for rivers can be delivered under most scenarios, which should help to consolidate the environmental benefits of recent wet conditions and build resilience ahead of the next dry period.

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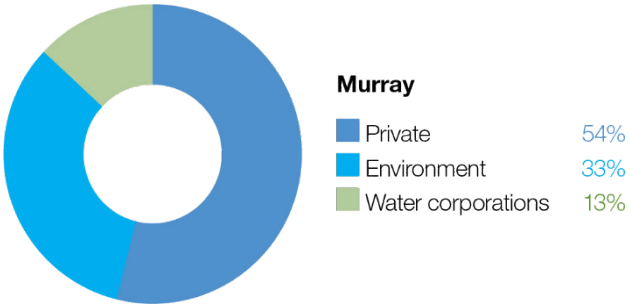
5.2 Victorian Murray system

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

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

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

Proportions of water entitlements in the Victorian Murray system held by private users, water corporations and environmental water holders on 30 June 2020



Traditional Owners have a unique connection to their lands and water, including what is referred to as the Murray River system. Traditional Owners within their traditional borders refer to the Murray in their own languages. For example, the Yorta Yorta People know the Murray as *Dhungulla*. They possess distinct cultural boundaries, language and cultural practices. The Victorian Murray system referred to in this plan includes waterways, storages, weirs, locks and regulators managed under state and federal legislation. This system overlays many Traditional Owner boundaries.

Within the Victorian Murray system, there are many significant floodplains and wetland systems covering the North East, Goulburn Broken, North Central and Mallee CMA areas. They are sites of significance for Traditional Owners, with tangible and intangible cultural connections dating back many thousands of years and continuing to the present day. The Barmah Forest, Kerang wetlands and the Hattah Lakes are internationally recognised Ramsar-listed sites due to the significance of their wetland types and the abundance and range of waterbird species that use them. Many other wetlands in the system are either nationally or regionally significant.

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

Victorian Murray system water availability

In 2021-22, allocations against high-reliability water shares reached 52 percent in August and 100 percent in October. Low-reliability water shares began receiving allocations in December and reached their full allocations in February. This is the first time Murray seasonal determinations reached maximum availability since the introduction of the current entitlement products in 2007. Spills from Hume Dam resulted in the deduction of most spillable carryover from 2020-21, as of 11 May 2022.

Prolonged periods of declared unregulated flow conditions in the Murray River enabled access to unregulated components of environmental entitlements and access to River Murray Unregulated Flows (RMUF). Victorian unregulated entitlements were primarily used to meet Murray floodplain demands at Gunbower, Hattah and the Lindsay Mulcra Wallpolla islands icon sites in spring, while RMUF was used for Murray River channel (Hume to the Coorong) water actions agreed by the Southern Connected Basin Environmental Watering Committee (SCBEWC). The strong resource position allowed the Barmah-Millewa Forest Environmental Water Account to be repaid much earlier in the year than normal, and it was used in combination with other holdings to meet Barmah-Millewa Forest demands in late winter and spring.

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Significant volumes were released from the Snowy system to the Murray system in 2021-22, which is likely to result in additional River Murray Increased Flows (RMIF) being available in the Murray system in May 2022. SCBEWC has the first option on RMIF, and it accepted 112,000 ML that it can use to meet Murray demands from June 2022 onwards and/or carry over into 2022-23.

Total water availability for the environment was high in 2021-22, with sufficient supply to meet planned Victorian Murray system demands and carryover needs for 2022-23. The high water availability allowed the VEWH to sell up to 12,000 ML of its allocation in autumn.

This summary covers water availability for all of the waterway systems described in section 5.2.

5.2.1 Upper Murray wetlands

System overview

The upper Murray wetlands are located on the Murray River floodplain between Lake Hume and Lake Mulwala. The wetland system includes the Ryans Lagoon wetland complex, which has two main lagoons: Ryans Lagoon 1 and Ryans Lagoon 2.

This is the first year the upper Murray wetlands have been included in the VEWH's seasonal watering plan and the first time water for the environment is planned to be delivered to the Ryans Lagoon wetland complex. The Ryans Lagoon wetland complex is a network of wetlands positioned downstream of the Lake Hume water storage and upstream of the Kiewa River confluence with the Murray River.

Flows into the complex are mainly influenced by regulated releases from Lake Hume, which travel via Ryans Creek, an anabranch of the Murray River. The complex begins to fill from Ryans Floodway when flows in the Murray River exceed 23,000 ML per day, but flows above 26,000 ML per day for extended periods are needed to completely fill both lagoons. High unregulated flows that move across the Kiewa River floodplain during wet conditions can also inundate the site. Since 2014, the maximum regulated flow from Lake Hume has reduced from 25,000 ML per day to less than 20,000 ML per day. These changes have greatly reduced the frequency of watering at Ryans Lagoon, which currently only fills if large, unregulated flows are released from Lake Hume or the reservoir spills.

Temporary pumps will be used to deliver water for the environment to restore the ecological health of the complex by providing a wetting and drying regime that is closer to the natural flow regime that existed before the regulation of the Murray River. Water can be pumped into Ryans Lagoon from the Ryans Lagoon floodway, which carries water when the flow in the Murray River exceeds 8,000 ML per day.

North East CMA is investigating options to improve watering regimes at other wetlands along the upper Murray floodplain.

Environmental values

North East CMA's *North East Waterway Strategy* recognises the Ryans Lagoon wetland complex as a high-value wetland complex, and it is listed as a nationally significant wetland in the *Directory of Important Wetlands in Australia*. The complex provides habitat for species listed under the Commonwealth *Environmental Protection and Biodiversity Conservation Act 1999* and the Victorian *Flora and Fauna Guarantee Act 1988*, including seven bird, three fish and one perennial plant species. Ecological surveys conducted at the site since 1975 have recorded 250 species of waterbugs and 29 species of waterbirds, including the Australian white ibis, great egret and rufous night heron. The complex also supports native wetland vegetation types that are expected to improve in condition once a seasonally aligned, more variable watering regime is re-instated.

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Environmental watering objectives in the upper Murray wetlands

Icon	Environmental objectives in the upper Murray wetlands
	Restore carbon and nutrient cycling within the wetlands to increase ecosystem productivity
	Increase habitat for native fish and increase their population
	Increase the extent of fringing and aquatic vegetation
	Provide feeding habitat for a range of waterbird species
	Increase the abundance and diversity of waterbugs to support aquatic food webs

Traditional Owner cultural values and uses

Traditional Owners have lived for tens of thousands of years on the upper Murray floodplain. Wetlands in the region have immense cultural value to Traditional Owners, including those represented by the Dalka Warra Mittung Aboriginal Corporation, the Dhudhuroa Waywurru Nations Aboriginal Corporation and the Duduroa Dhargal Aboriginal Corporation.

North East CMA is building relationships with each corporation, and it aims to support Traditional Owners' input to planned environmental flows at the Ryans Lagoon wetland complex in the coming years. In the long term, North East CMA aims to support the defined objectives of Traditional Owners for the complex and Traditional Owners' obligations to Country more broadly.

Traditional Owners from Duduroa Dhargal Aboriginal Corporation have expressed an interest in developing a cultural plan for the Ryans Lagoon wetland complex. They have also communicated that they have little internal capacity or time to do so at present.

Social, recreational and economic values and uses

In planning the potential watering actions in Table 5.2.1, North East CMA considered how environmental flows could support values and uses, including:

- water-based recreation (such as fishing)
- waterway recreation and amenity (such as birdwatching and camping)
- community events and tourism (such as visitation by schools, Landcare groups and other community groups)
- socio-economic benefits (such as incidental visitation to local towns and businesses).

Recent conditions

The upper Murray wetlands experienced above-average rainfall and temperatures for most of 2021-22. Inflows to Hume Dam were above average, and the storage reached 100 percent capacity in early spring for the first time since 2016. Additional water was released periodically from Hume Dam from September 2021 to create airspace and manage flood risk. These releases generated a peak flow in the Murray River below the dam of 33,000 ML per day in late November, which filled Ryans Lagoon 1 and partially filled Ryans Lagoon 2. This was the first time the site had received flows since 2016.

The desired watering regime for the wetland complex is to fill in spring each year and allow a partial drawdown over summer and autumn. The deeper parts of each lagoon are expected to retain permanent water that will support native fish populations, and the variable wetting and drying of the lagoons' shorelines will improve the condition and diversity of wetland plant communities and promote carbon and nutrient cycling. The desired watering regime for the Ryans Lagoon wetland complex has only been achieved once in the past 10 years: in 2016-17. Flows that entered the complex between 2012-14 and again in 2021-22 were insufficient to completely fill both lagoons. An ecological assessment in 2019 found the wetland complex to be in moderate-to-good condition but rated the flow regime as poor. Natural flows that partially filled the wetlands in 2021-22 are expected to have improved the overall condition of the complex. However, annual, temporary pumping to the site in future years will aim to reinstate a more natural water regime, to significantly improve ecological outcomes.

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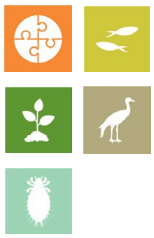
Scope of environmental watering

Table 5.2.1 describes the potential environmental watering actions in 2022-23, their expected watering effects (that is, the intended physical or biological effects of the watering action) and the longer-term environmental objectives they support. Each environmental objective relies on one or more potential environmental watering actions and their associated physical or biological effects.

Table 5.2.1 Potential environmental watering actions, expected watering effects and associated environmental objectives for the upper Murray wetlands

Potential environmental watering action	Expected watering effects	Environmental objectives
Ryans Lagoon 1 and Ryans Lagoon 2 (fill in spring)	• Mobilise carbon and nutrients within the wetlands to support wetland processes • Maintain permanent, deep, open-water habitat that supports food resources for waterbirds and native fish • Inundate wetland margins to provide refuge and feeding habitat for small- and large-bodied native fish • Increase soil moisture to promote the growth of fringing vegetation and the surrounding river red gum community • Inundate beds of aquatic and semi-aquatic vegetation to stimulate growth and increase their extent • Prevent the encroachment of river red gum saplings into deep areas of the wetland • Inundate wetland margins to provide habitat for waterbugs and foraging opportunities for waterbirds	

Scenario planning

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

Ryans Lagoon 1 and Ryans Lagoon 2 would have naturally filled every year before the river was regulated, so watering in spring is a high priority under all climate scenarios. Water for the environment (delivered via temporary pumps) will likely be needed to fill both lagoons under drought, dry and average climate scenarios. High unregulated flows and natural floods are likely to inundate the wetlands under a wet climate scenario, and water for the environment will only be used under a wet scenario to top up water levels in each lagoon if they do not fill naturally.

Table 5.2.2 Potential environmental watering for the upper Murray wetlands under a range of planning scenarios

Planning scenario	Drought	Dry	Average	Wet
Expected river conditions	• No unregulated flow below Hume Dam • Regulated flow from Hume Dam is likely to connect the Ryans Lagoon floodway to allow pumping into Ryans Lagoon 1 and Ryans Lagoon 2	• Unregulated flow is unlikely below Hume Dam • Regulated flow from Hume Dam will connect the Ryans Lagoon floodway to allow pumping into Ryans Lagoon 1 and Ryans Lagoon 2	• Periods of unregulated flow below Hume Dam • Regulated and unregulated flow from Hume Dam and/or flow from the Kiewa River will connect the Ryans Lagoon floodway to allow pumping into Ryans Lagoon 1 and Ryans Lagoon 2	• Regular periods of unregulated flows below Hume Dam and from the Kiewa River may provide partial inundation to Ryans Lagoon 1 and Ryans Lagoon 2
Expected availability of water for the environment	• 170 ML			
Potential environmental watering – tier 1 (high priorities)	• Ryans Lagoon 1 and 2 (fill in spring)			

Planning scenario	Drought	Dry	Average	Wet
Possible volume of water for the environment required to achieve objectives	• 170 ML (tier 1a)			• 0-170 ML (tier 1a)

5.2.2 Barmah Forest

System overview

The Barmah Forest is located within Yorta Yorta's traditional boundaries. The Barmah-Millewa Forest covers 66,000 ha and spans the New South Wales – Victoria border between Tocumwal, Deniliquin and Echuca (Figure 5.2.1). The Barmah-Millewa Forest is listed under the Convention on Wetlands of International Importance (the Ramsar Convention), is listed in the *Directory of Important Wetlands in Australia*, and it is one of six Living Murray icon sites. The forest's Victorian components are the Barmah National Park and part of the River Murray Reserve, covering 29,305 ha of forest and wetlands that support a vast range of significant plant and animal species and culturally significant sites to the Yorta Yorta.

The wetlands throughout the forest continue to provide a constant source of nutritional foods and significant fibres for the Yorta Yorta People. It is also evident that the resources in the landscape were used to manufacture canoes, shields and carrying devices.

Flooding in the Barmah-Millewa Forest depends on flows in the Murray River. A natural narrowing of the river (commonly referred to as the Barmah Choke) restricts flow and causes overbank flooding when flows below Yarrawonga Weir exceed the channel's capacity. This restriction influences both the operation of Yarrawonga Weir and the magnitude of environmental flows that can be delivered to the forests. The Yorta Yorta People see this narrow part of *Dhungulla* as a culturally significant creation story, and it provides ecosystem services both from a culturally and environmentally significant viewpoint. The name 'Barmah Choke' is culturally inappropriate for the Yorta Yorta, and it is seen as a negative way to view their traditional lands and waters. Yorta Yorta People may refer to this as the 'Pama Narrows', or more simply 'The Narrows'.

Before the river was regulated, Barmah-Millewa Forest was regularly flooded with high flows from rainfall and snowmelt in winter and spring. These regular floods shaped a rich, productive forest environment. The construction and operation of Hume Dam and Dartmouth Dam have greatly reduced the size and frequency of natural winter/spring floods in Barmah-Millewa Forest.

Also, operational deliveries to supply water to users downstream of The Narrows can cause unseasonal, low-level floods, which can damage the forest and banks of the river depending on the timing and volume of the flows. Country for the Yorta Yorta People continues to change, but the changes have been rapid post-settlement due to infrastructure installation and river regulation. This has changed Country culturally and environmentally for the Yorta Yorta People. Their language word for water is *wala*, and it includes if an area is wet but may imply to others a 'flood', which is viewed as negative water.

The delivery of irrigation water during summer/autumn is now managed to minimise unseasonal flooding of the forest. Regulators along the banks of the Murray River that control flow between the river and the forest remain closed during summer and autumn to restrict flow through low-lying flood runners to simulate natural conditions. The delivery of water to Barmah-Millewa Forest is also limited by a flow constraint below Yarrawonga Weir to minimise impacts to adjacent farming operations in NSW. The current constraint limits regulated flows to a maximum river level of 3.3 m at the Tocumwal gauge (about 18,000 ML per day downstream of Yarrawonga Weir), subject to various conditions. Regulated flow up to a river level of 3.0 m on the Tocumwal gauge (about 15,000 ML per day downstream of Yarrawonga Weir) can be delivered at any time during the year and is not subject to conditions. To overcome this constraint, most environmental flows are shared between Barmah and Millewa forests to deliver water to low-lying wetlands in each forest at least every second year. It is currently not possible to achieve the desired flood depth and duration for floodplain marsh vegetation in both forests at the same time without larger natural flooding.

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

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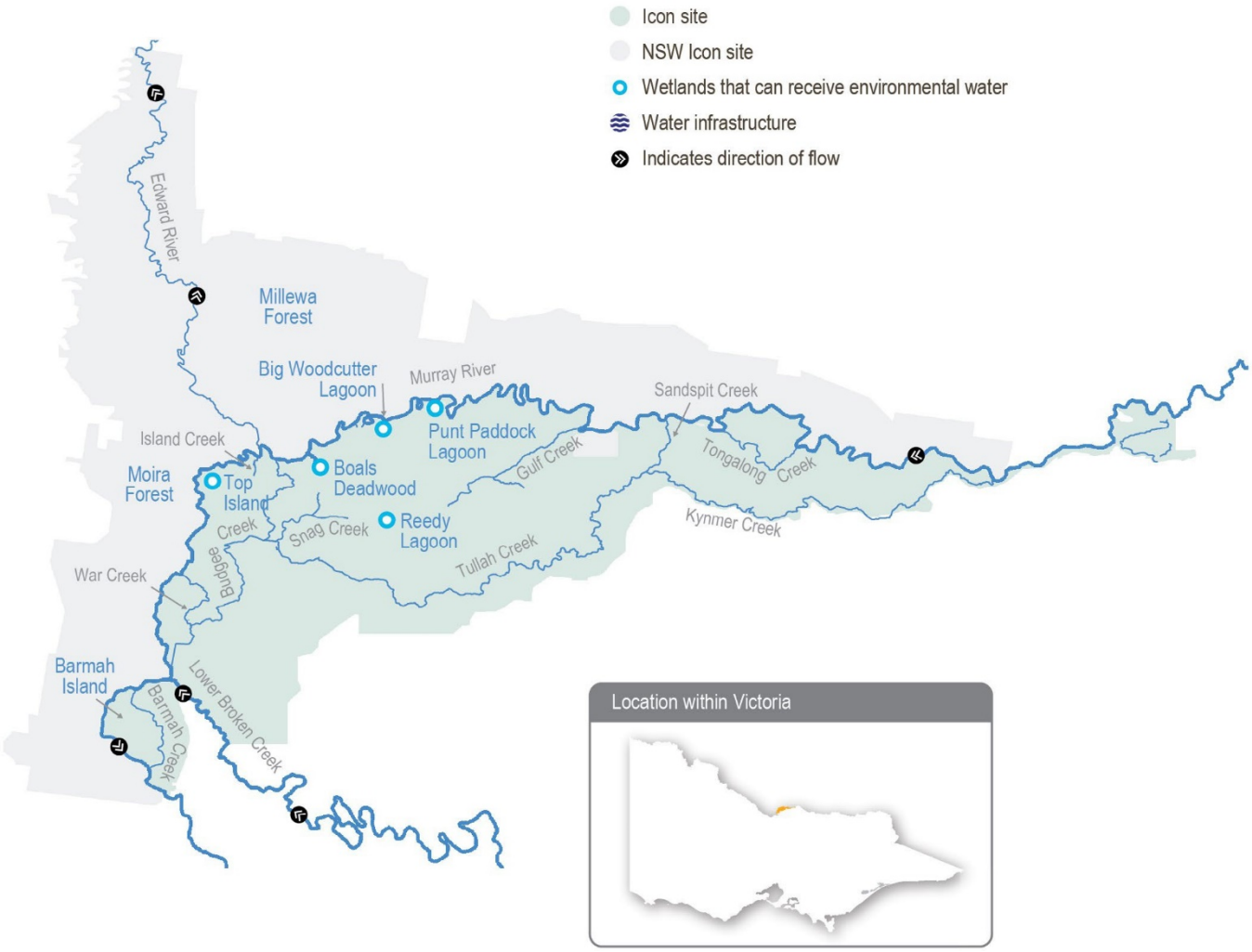
Figure 5.2.1 Barmah Forest



Environmental values

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

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Environmental watering objectives in the Barmah Forest

Icon	Environmental objectives in the Barmah Forest
	Enable carbon and nutrient cycling between the floodplain and river through connectivity
	Maintain or increase habitat for native fish and increase their population
	Maintain or increase frog populations
	Protect forest waterways from increased erosion
	Maintain turtle populations, including the broad-shelled turtle
	Enhance the health of river red gum communities and aquatic vegetation in the wetlands and watercourses and on the floodplain Promote the growth of floodplain marsh vegetation communities, with a particular focus on increasing the extent of Moira grass
	Provide feeding and nesting habitat for the successful recruitment of colonial nesting waterbirds
	Reduce the risk of low-oxygen events in summer

Traditional Owner cultural values and uses

"We are the First People of this place. We were here even before the Murray River flowed through Barmah."
— *Uncle Des Morgan, Yorta Yorta Elder, Joint Management Plan for Barmah National Park*

Yorta Yorta are joint managers of Barmah National Park with Parks Victoria under a Traditional Owner Land Management Agreement with the State of Victoria. Goulburn Broken CMA met with the Yorta Yorta Nation Aboriginal Corporation during the environmental flows planning process to obtain input and feedback about planned deliveries of water for the environment in Barmah Forest. Yorta Yorta Traditional Owners developed the *Yorta Yorta Whole-Of-Country Plan 2021-2030*, and they were involved in developing the *Joint Management Plan for Barmah National Park*. Both plans have informed planned watering actions. Ongoing interaction on land and water management at Barmah also occurs through the Living Murray Indigenous Partnerships Program.

Yorta Yorta values are more than 'stones and bones'. They encompass an inherent and living connection to land (*woka*), water (*wala*) and caring for Country.

Examples of Yorta Yorta cultural values and uses in Barmah Forest that are supported through water for the environment delivery include:

- maintaining refuges, which protect turtles, an important totemic species for the Yorta Yorta People
- watering to support floodplain marsh vegetation, which includes important food, fibre and medicinal plants (such as sneezeweed and weaving sedge)
- improving the health of river red gums, which has benefits for important Yorta Yorta sites and significant markings (such as a scarred tree) and furthers connections to Country
- broader restoration to achieving healthy Country.

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Social, recreational and economic values and uses

In planning the potential watering actions in Table 5.2.3, Goulburn Broken CMA considered how environmental flows could support values and uses, including:

- water-based recreation (such as boating, fishing, kayaking and canoeing)
- riverside recreation and amenity (such as birdwatching, picnicking, photography, camping and the general physical, mental and social benefits of communing with nature)
- community events and tourism (such as boat tours)
- socio-economic benefits (such as for apiarists and irrigation diverters).

Recent conditions

La Niña events generally result in above-average rainfall years, but back-to-back events in 2020-21 and 2021-22 have resulted in near-average rainfall years for Barmah Forest (as measured at Echuca). Maximum temperatures were also about average for both years.

While local rainfall is important for the forest, upstream Murray River and tributary flows (such as from the Ovens and Kiewa rivers) provide the natural, overbank floods that the forest needs. Rainfall in the Ovens and Kiewa catchments was about average to above average during 2021-22, resulting in some minor, unregulated events during winter and spring. Rainfall in the upper Murray above Hume Dam was above average to very much above average during 2021-22, which resulted in Hume Dam filling and multiple spills — managed high releases — from the storage. These flows combined to deliver four flood peaks of 30,000 to 45,000 ML per day downstream of Yarrawonga Weir during winter and spring 2021, with the largest event in September. While important for the health of the forest, the 2021-22 events were relatively small, inundating about 45 percent of the Barmah Forest floodplain. For context, the wet spring of 2016 resulted in a peak flow of about 180,000 ML per day downstream of Yarrawonga Weir, which inundated an estimated 98 percent of the forest floodplain.

In 2021-22, allocations against high-reliability water shares reached 52 percent in August and 100 percent in October. Low-reliability water shares began receiving allocations in December and reached their full allocations in February. This is the first time Murray seasonal determinations reached maximum availability since the introduction of the current entitlement products in 2007. Spills from Hume Dam resulted in the deduction of most spillable carryover from 2020-21. Section 5.2 has more information about the resource position of water for the environment in the Victorian Murray system during 2021-22.

Water for the environment in Barmah Forest was delivered in line with the average climate scenario in 2021-22. All planned deliveries for the year were fully or partially met, noting autumn-winter (May to June 2022) flows in the Murray River channel are planned but were yet to be delivered at the time of preparing this publication.

Water for the environment was delivered within operational limits to fill in gaps between natural events. Specific actions included maintaining a flow just below 3 m at Tocumwal (about 15,000 ML per day downstream of Yarrawonga Weir) throughout spring and managing recession flows back to below channel capacity in summer. Having a gradual flow recession during December is essential for native fish to move from the floodplain to the river channel without being stranded in forest anabranches. Fish movement was monitored during the recession flow, and the results will be used to inform the magnitude and timing of similar actions in spring 2022-23 and beyond.

Regulators that control flow between the Murray River and Barmah Forest are closed during summer and autumn to prevent high deliveries to downstream irrigation customers from inundating the forest when it would normally be drying. The exception is where water for the environment is diverted into individual wetlands within the forest (such as Boals Deadwood) to improve the success of any waterbird breeding events that may have been triggered by the forest's inundation in spring. High summer rainfall in the upper Murray catchment triggered some small spills from Hume Dam, and the Barmah Forest regulators were partially opened to reduce the flooding risk to public and private infrastructure. The unseasonal re-wetting of parts of the Barmah floodplain caused some low-oxygen blackwater to develop and flow into the Murray and Edwards rivers. The impact was minor, and no fish deaths were recorded.

A wet climate forecast for winter 2022 on the back of the above-average conditions in 2021-22 resulted in a potential opportunity to commence connecting the forest and the river earlier in winter than in recent years. Increased autumn-winter low flows are planned for June 2022.

Scope of environmental watering

Table 5.2.3 describes the potential environmental watering actions in 2022-23, their expected watering effects (that is, the intended physical or biological effects of the watering action) and the longer-term environmental objective(s) they support. Each environmental objective relies on one or more potential environmental watering actions and their associated physical or biological effects.

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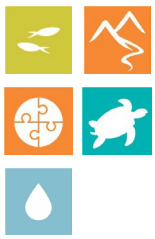
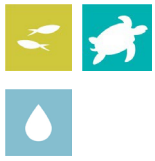
Table 5.2.3 Potential environmental watering actions, expected watering effects and associated environmental objectives for the Barmah Forest

Potential environmental watering action	Expected watering effect(s)	Environmental objective(s)
Winter/spring forest low flow to various waterways in Barmah Forest (variable flow rates and duration during July to November 2022 and June 2023)	• Provide a gradual connection of waterways with the Murray River to minimise erosion within those waterways • Provide flow in forest waterways to ensure adequate refuge pools persist for native fish and turtles • Provide adequate depth and connection between floodplain waterways and the river to facilitate the movement of native fish • Remove accumulated organic matter from waterways to cycle carbon to the river system and minimise the risk of hypoxic blackwater by ensuring throughflow	
Winter/spring/summer low flow (8,500-18,000[1] ML/day below Yarrawonga Weir during August to December)	• Maintain a sufficient water level in the Murray River main channel to prevent Murray cod from abandoning their nests, increase juvenile survival and improve dispersal opportunities	
Spring/summer fresh(es) in the Murray River channel (one to three freshes that increase flow by at least 500 ML/day and maintain it for two to eight days during October to December)	• Provide variable water levels once water temperatures exceed 22oC to trigger spawning of native fish species, primarily silver perch	
Spring/summer/autumn freshes to Gulf and Boals creeks (100 ML/day for three to five days as required during November to April)	• Maintain critical refuge pools to provide habitat for native fish and turtles • Flush refuge pools to maintain water quality	
Spring/summer/autumn low flow to floodplain waterways, including Sandspit, Gulf, Big Woodcutter, Boals and Island creeks and Punt Paddock Lagoon (200 ML/day for 30 to 60 days during November to April)	• Replenish refuge pools in permanent waterways to maintain water quality, fish and turtle populations • Maintain connectivity between the forest and the river • Remove accumulated organic matter, cycle carbon to the river system and minimise the risk of hypoxic blackwater	
Fill or top up Boals Deadwood, Harbours Lake, Reedy Lagoon and Top Island wetlands (200-400 ML/day for four and a half months during September to February)	• Provide a cue to initiate waterbird breeding and maintain a depth of at least 0.5 m beneath reed bed nesting breeding colonies • Maintain wetting duration and depth for growth of wetland vegetation	
Spring wetting of floodplain marshes (variable flow rates of > 9,500-18,000[1] ML/day below Yarrawonga Weir for three months during September to December)	• Inundate open plains to sufficient depth and for sufficient duration to allow the growth of floodplain marsh vegetation • Inundate forest wetlands and low-lying floodplain areas to create foraging opportunities for waterbirds and increase available habitat for turtles, frogs and small-bodied native fish	

Potential environmental watering action	Expected watering effect(s)	Environmental objective(s)
Autumn/winter low flow in the Murray River (1,800-12,000 ML/ day downstream of Yarrawonga during May to June)	• Increase water depth in the Murray River channel to provide habitat for large-bodied native fish in the Murray River and unregulated anabranches in Barmah-Millewa Forest	

1 The maximum flow constraint is a level of 3.3 m at the Tocumwal gauge in the Murray River, estimated at 18,000 ML/day downstream of Yarrawonga Weir. The maximum flow rate actually delivered may vary for these actions.

Scenario planning

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

The ecological objectives at Barmah-Millewa Forest require sustained flows in the Murray River through winter and spring. Flow control structures are used to direct water from the Murray River channel into the forest. The same structures facilitate the later return of most of that water back to the river, transporting carbon and nutrients for use downstream. Current flow constraints mean water will be biased towards Barmah Forest in 2022-23, aiming to meet depth and duration targets for wetlands. These arrangements alternate between Barmah and Millewa forests each year.

Demands for water for the environment in Barmah Forest vary significantly in response to seasonal conditions. Variable winter/spring low flow and spring/summer freshes are required under all scenarios. The variable winter/spring low flow aims to maintain habitat and movement opportunities for aquatic animals (such as native fish) and is achieved by keeping the regulating structures open and allowing water to move in and out of the forest in response to normal flow variation in the Murray River. The spring/summer freshes are achieved by providing variations in the flow rate in the Murray River below Yarrawonga Weir that trigger the spawning of silver perch.

Under drought and dry conditions, potential environmental flows will primarily aim to maintain water levels and water quality in refuge habitats within the forest to sustain fish and turtle populations. Actions to achieve these objectives require relatively small volumes of water to be directed into the forest, and they are unlikely to return much water to the Murray River for downstream use.

The winter/spring/summer low flow in the Murray River channel will maintain sufficient water levels for successful Murray cod nesting and recruitment under dry to wet climate scenarios. This watering action aims to increase the Murray cod population and improve the recovery of this species. The volume needed to achieve this depends on the contribution of natural flows and the delivery of operational water downstream through The Narrows. This action will provide environmental return flows downstream for use at other sites along the Murray River.

Under the average or wet scenarios, the focus shifts to building resilience in the system by increasing the ecological response to unregulated flooding events. Specific actions under the average or wet scenarios may include extending the duration of unregulated flooding to increase the vigour and resilience of wetland communities (such as Moira grass plains) in floodplain marshes or extending watering in river red gum forests to maintain the health of the trees. These actions may require large volumes of water to be directed into the forest, with water for the environment provided as a directed release from Hume Dam targeting specific flow rates downstream of Yarrawonga Weir and managed using forest regulators. Most of the water used for these actions is eventually returned to the Murray River through the natural shedding action of the floodplain.

A prolonged, low-level, spring watering event in 2022-23 is desirable to help floodplain vegetation flower, set seed and recruit. Some floodplain inundation will occur when the flow downstream of Yarrawonga exceeds about 9,500 ML per day. However, a greater flow will inundate more of the floodplain to a greater depth and therefore deliver a better outcome for floodplain vegetation and also benefit native fish, frogs, turtles and waterbirds. Ideally, the flow will be delivered up to 3.3 m on the Tocumwal gauge (about 18,000 ML per day downstream of Yarrawonga Weir) to inundate larger areas to an appropriate depth in Barmah and Millewa forests.

Regulators may be used to divert water to selected wetlands under various scenarios to support any significant waterbird breeding that is triggered by spring inundation.

Spring wetting of floodplain marshes will provide environmental benefits under all climate scenarios in 2022-23. It is a high priority under dry to wet scenarios but would only be delivered in certain circumstances under the drought scenario. For example, the size of a multi-site environmental watering action supporting whole-of-River-Murray and/or downstream environmental objectives during winter and spring may increase flow through Barmah Forest. This may be possible in 2022-23 as water availability in the Murray system is forecast to be high, even under a drought scenario. Another possibility is 'piggybacking' operational transfers from Hume Dam with water for the environment. The volume of water for the environment required to achieve the floodplain marsh flow objectives under the drought climate scenario depends on demands for multi-site environmental events or operational transfers, and it is therefore not estimated in Table 5.2.4 below.

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Table 5.2.4 Potential environmental watering for the Barmah Forest under a range of planning scenarios

Planning scenario	Drought	Dry	Average	Wet
Expected river conditions	• Unregulated flow periods are unlikely • Flow in the Murray River will remain within the channel all year	• Some small, unregulated flow in late winter/spring • Low chance of overbank flow in late winter/spring	• Likely chance of small-to-medium unregulated flow in winter/spring • Likely chance of overbank flow in winter/spring	• High probability of moderate to large unregulated flow in winter/spring • Expected large overbank flow
Potential environmental watering – tier 1 (high priorities)[1]	• Winter/spring forest low flow • Spring/summer fresh(es) (one to three freshes) • Spring/summer/ autumn freshes (to Gulf and Boals creeks)	• Winter/spring forest low flow • Winter/spring/ summer low flow • Spring/summer fresh(es) (one to three freshes) • Spring/summer/ autumn low flow • Fill or top up Boals Deadwood, Harbours Lake, Reedy Lagoon and Top Island wetlands • Spring wetting of floodplain marshes	• Winter/spring forest low flow • Winter/spring/ summer low flow • Spring/summer fresh(es) (one to three freshes) • Spring/summer/ autumn low flow • Fill or top up Boals Deadwood, Harbours Lake, Reedy Lagoon and Top Island wetlands • Spring wetting of floodplain marshes • Autumn/winter low flow (in Murray River)	• Winter/spring forest low flow • Winter/spring/ summer low flow • Spring/summer fresh(es) (one to three freshes) • Spring/summer/ autumn low flow • Fill or top up Boals Deadwood, Harbours Lake, Reedy Lagoon and Top Island wetlands • Spring wetting of floodplain marshes • Autumn/winter low flow (in Murray River)
Potential environmental watering – tier 2 (additional priorities)	• Spring wetting of floodplain marshes	• N/A		
Possible volume of water for the environment required to achieve objectives[2]	• 8,500 ML (tier 1)	• 550,000 ML (tier 1)	• 200,000 ML (tier 1)	• 130,000 ML (tier 1)

1 Tier 1 potential environmental watering at Barmah Forest is not classified as tier 1a or 1b because the water available for use is shared across various systems, and it is not possible to reliably determine the supply specifically available for Barmah Forest.

2 The possible volumes of water for the environment required in Barmah Forest are estimates and highly variable, depending on factors such as seasonal conditions and the contributions of operational and/or unregulated flows. Much of the water for the environment delivered to Barmah Forest is returned to the Murray River — around 80 percent under the dry to wet climate scenarios — and can be reused at downstream sites.

5.2.3 Gunbower Creek and Forest

System overview

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

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

Gunbower Creek is a natural creek that has been modified to supply irrigation water from the Murray River to the Torrumbarry Irrigation Area. There are 12 lagoons, largely located in the upper reaches of the creek system, that are permanently or seasonally connected to Gunbower Creek. Water for the environment is used in Gunbower Creek to improve habitat for native fish, especially Murray cod.

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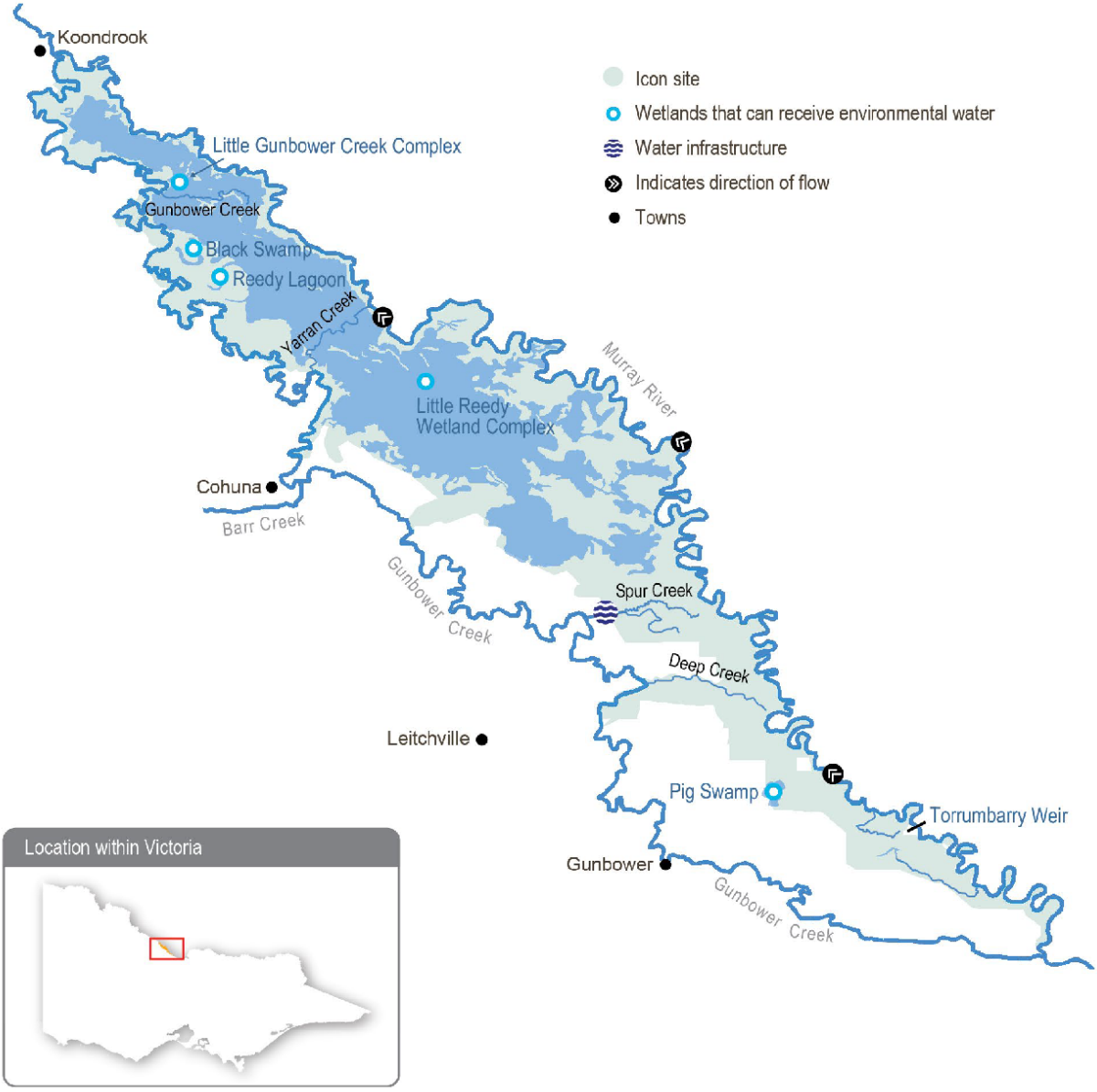
The Living Murray environmental works program in the middle and lower forest was completed in 2013. The works allow up to 4,500 ha of the wetlands and floodplain to be watered with considerably less water than would be required if the watering infrastructure was not in place. The works enable efficient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

Figure 5.2.2 Gunbower Creek and Forest



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Environmental values

Gunbower Forest contains many important environmental values. It includes rare and diverse wetland habitats and large areas of remnant vegetation communities (such as river red gum forest and woodlands). It is home to vulnerable and endangered plants and animals, including river swamp wallaby grass, wavy marshwort, Murray-Darling rainbowfish and eastern great and intermediate egrets. Gunbower Forest also supports internationally recognised migratory waterbird species.

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

Environmental watering objectives in Gunbower Creek and Forest

Icon	Environmental objectives in Gunbower Creek and Forest
	Provide feeding, breeding and refuge habitat for small-bodied native fish (such as Murray-Darling rainbow fish) in forest wetlands Maintain and improve populations of large-bodied native fish (such as Murray cod) in Gunbower Creek
	Increase the diversity and abundance of native frog species within the forest
	Maintain the population of freshwater turtles by providing suitable feeding, breeding and refuge habitat
	Support carbon and nutrient cycles in the forest and wetlands and periodically deliver carbon and nutrients from the forest to adjacent waterways to support food webs
	Maintain and improve the health and increase the abundance of native vegetation in permanent and semi-permanent wetlands Improve the health of river red gums and black box communities
	Provide feeding, breeding and refuge habitat for waterbirds, including colonial nesting species (such as egrets, cormorants and herons)
	Maintain and improve water quality in Gunbower Creek

Traditional Owner cultural values and uses

The Barapa Barapa are the Traditional Owners in the middle and lower area of Gunbower Forest, and the Yorta Yorta are the Traditional Owners in the upper Gunbower Forest.

North Central CMA seeks engagement and input from both Traditional Owner groups when undertaking annual water for the environment planning and throughout the year as part of the Living Murray Indigenous Partnerships Program.

Yorta Yorta custodians and Barapa Barapa custodians have clearly expressed their aspirations for an active role in the management of land and water, to fulfil custodianship obligations and contribute to improvements in the health of Country.

Yorta Yorta and Barapa Barapa Traditional Owners have provided feedback on watering priorities for 2022-23 in Gunbower Forest.

Increasing the involvement of Traditional Owners in the planning and management of environmental flows and ultimately providing opportunities to progress towards self-determination within the environmental watering program is a core commitment of the VEWH and its agency partners. This is reinforced by a range of legislative and policy commitments, including the *Water Act 1989*, the Victorian Aboriginal Affairs Framework, the 2016 *Water for Victoria* and in some cases, agreements under the *Traditional Owner Settlement Act 2010*.

Where Traditional Owners are more deeply involved in the planning and/or delivery of environmental flows for a particular site, their contribution is acknowledged in Table 5.2.7 with an icon. The use of this icon is not intended to indicate that these activities are meeting all the needs of Traditional Owners but is incorporated in the spirit of valuing their contribution and indicating progress towards deeper involvement.

	Watering planned and/or delivered in partnership with Traditional Owners to support cultural values and uses

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Barapa Barapa Traditional Owners have been working in partnership with North Central CMA to deliver the Water for Country project in Gunbower Forest since 2015. The Water for Country project builds on the work of the previous Barapa Barapa Cultural Heritage Mapping of Lower Gunbower Forest project, delivered in 2013-14, to map a catalogue of cultural heritage assets in the forest. The Water for Country project aims to investigate how Traditional Owners' cultural and spiritual values may be better represented in water management. In 2018, the Water for Country group evolved to also include Wamba Wemba Traditional Owners and continues to have a focus on Gunbower Forest.

Barapa Barapa Wamba Wemba Water For Country project members identified a range of opportunities for 2022-23 watering to support cultural values, which Table 5.2.5 shows.

Table 5.2.5 Cultural values and uses at Gunbower Forest as identified by the Barapa Barapa Wamba Wemba Water For Country project

Value/use	How the value/use will be considered by environmental flows in 2022-23
Cultural plants, cultural practices	• Water in wetlands and on the floodplain from deliveries of water for the environment and natural flooding supports culturally important plants throughout Gunbower Forest and allows the continuation of cultural practices, including harvesting of food, medicine and weaving plants. • The watering actions via the Hipwell channel in 2022-23 will support cultural plants that Barapa Barapa Traditional Owners value and provide opportunities for cultural practices to continue. • The amount of cultural resources available is linked to the scale of watering that can be achieved. Floodplain watering via the Hipwell channel provides a greater amount of resources and enables abundant harvests with less travel and effort to harvest the desired amount of resources. • Barapa Barapa Traditional Owners recognise the value of resources that occur on the drawdown after the inundation of the forest floodplain, providing food for animals and cultural plants (such as old man weed). This can be supported by allowing wetlands to draw down naturally after receiving water to expose mudflats. • Having a diversity of habitat and vegetation responses is a priority for Barapa Barapa Traditional Owners. They consider it important to have a range of water depths, which creates a more diverse vegetation response and results in a variety of resources becoming available over a longer period. • Delivering water to the floodplain supports this by inundating wetlands of varying depth and condition, which supports a variety of cultural and ecological values.
Healthy Country	• Providing drought refugia and maintaining areas with healthy habitat is a high priority for Barapa Barapa Traditional Owners. In the absence of natural flooding, they feel it is important to ensure that water is delivered to healthy areas (such as Reedy Lagoon) that elicit a good vegetation response and can support wetland and forest fauna. • Deliveries of water for the environment will ensure water is present on the floodplain and in high-priority wetlands regardless of whether there is flooding. This will provide refuge habitat for forest fauna, and the delivery of water in Reedy Lagoon ensures high-quality habitat is available. • Barapa Barapa Traditional Owners have also expressed the importance of looking after areas that are in good condition by conducting follow-up watering. This will be done by delivering the Hipwell channel environmental watering event to build on outcomes achieved by the lower landscape watering in 2022.
Cultural heritage	• Barapa Barapa Traditional Owners value having water in natural creeks and billabongs off main wetlands, which can contain cultural heritage sites, including earth mounds and a large canoe tree on the edge of a large flood runner. • Delivering water to the floodplain supports this with water flowing through natural creeks and floodrunners on the floodplain. Deliveries of water for the environment result in lower levels than natural flooding, which can ensure that earth mounds or other cultural heritage are not overtopped and harmed. • Barapa Barapa Traditional Owners have noted that areas of black box and river red gum have cultural heritage values, but the changed watering regime since regulation and climate change is causing the encroachment of black box into areas previously dominated by river red gum. Barapa Barapa Traditional Owners expressed the desire to preserve the tree community that was historically present, which is supported by the delivery of water to the floodplain. The lower landscape regulators can target small areas of river red gum, and the Hipwell channel watering planned in 2022-23 will inundate large areas of river red gum and potentially suppress black box encroachment within the flood footprint.

Value/use	How the value/use will be considered by environmental flows in 2022-23
Cultural practices	• Barapa Barapa Traditional Owners have aspirations to reintroduce traditional fish traps into natural creeks within Gunbower Forest. The flood runners around the Little Gunbower Creek Complex have been identified as potential trial sites, and opportunities will be provided to pursue this in spring 2022. • Traditional Owners have indicated that a smoking ceremony should be a regular activity each year when water is delivered, as it is something that their ancestors would have done when the floodwaters arrived and would represent a restoration of an important cultural practice. The timing of deliveries of water for the environment will be communicated to Traditional Owners so cultural opportunities can be realised.
Cultural resources	• Barapa Barapa Traditional Owners have expressed that the ongoing survival of fish populations is important as a food resource. Wetland fish populations persisting in the Gunbower Forest wetlands following the 2021 watering event will be supported by the large-scale Hipwell channel watering event, ensuring a resident fish population persists across multiple years.

The Barapa Barapa Wamba Wemba Water for Country project has led to the creation of the Barapa Barapa Cultural Watering Objectives Framework, which is a guiding document to ensure cultural priorities and outcomes are considered and incorporated in the planning for and management of water for the environment. The framework considers cultural objectives matched with hydrological considerations, indicators and measures for monitoring success, which Table 5.2.6 shows. These objectives are considered in conjunction with the environmental objectives and expected watering effects for the potential environmental flows shown in Table 5.2.7.

Planning for water for the environment in 2022-23 included a field visit to Gunbower Forest in early 2022. The discussion during the field visit focused on the current condition of the forest, particularly around the wetlands and the dry river red gum forest, and how the 2022-23 watering actions will continue to support cultural objectives and protect cultural heritage.

Applying the framework during seasonal watering proposal engagement with the Barapa Barapa Wamba Wemba Water for Country project members will ensure that planned environmental flows incorporate Barapa Barapa Traditional Owners' cultural aspirations and that water managers are culturally informed when delivering water for the environment.

All potential environmental watering actions in Table 5.2.7 provide the opportunity to support Barapa Barapa cultural values and objectives, but achieving them will depend on climatic conditions.

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Table 5.2.6 Barapa Barapa cultural objectives for environmental flows in Gunbower Forest 2022-23 (from the Barapa Barapa Cultural Watering Objectives Framework)

Cultural objective	Hydrological aim	Indicator	Measure	Watering action
Promote and maintain healthy and abundant native fish communities in Gunbower Creek and Gunbower Forest	• Presence of water in wetlands before spring to support fish spawning events	• Presence of native fish spawning • Native fish populations show a range of ages	• Fish surveys, larval sampling	• Floodplain watering and wetland top-ups
	• Presence of water in deep wetlands, so that fish can survive for longer	• Presence of native fish following watering event	• Fish surveys	
Promote the natural flow of water	• Water flows via natural flow paths to culturally important sites	• Presence of water at culturally significant sites (e.g. fish ponds)	• Photo points, site surveys	
	• Presence of healthy looking and smelling forest	• Presence of healthy canopies and good ground cover on the forest floodplain	• Plant surveys	
Promote and maintain healthy cultural plants and resources	• Presence of water in small wetlands and depressions to provide resources across the forest, particularly in dry years	• Presence of food and fibre resources distributed across the forest	• Cultural harvests, plant surveys, seed collection	
	• Presence of water in wetlands which are healthy	• A diverse range of plants, animals and insects living in harmony	• Results of monitoring activities (e.g. macroinvertebrate surveys, flora and fauna surveys)	
Promote healthy waterbird populations	• Presence of water in wetlands that support waterbird breeding	• Presence of waterbird breeding	• Waterbird surveys, spring/summer surveys for eggs	

Social, recreational and economic values and uses

In planning the potential watering actions in Table 5.2.7, North Central CMA considered how environmental flows could support values and uses, including:

- water-based recreation (such as boating, canoeing, duck hunting, fishing, stand-up paddle boarding and water skiing)
- riverside recreation and amenity (such as birdwatching, camping, photography and walking)
- community events and tourism (such as park visitation, tour and activity operators)
- socio-economic benefits (such as consumptive water users, including irrigation and domestic use, timber harvesting and education).

Recent conditions

During 2021-22, rainfall and temperatures at Gunbower Forest and surrounding areas were close to the long-term average. Rainfall in north-east Victoria and south-east New South Wales was well above the long-term average, and it delivered high inflows to the Murray system and its storages. The wet conditions triggered managed releases from Hume Reservoir and frequent high flows in tributaries such as the Kiewa, Ovens and Goulburn rivers, which ensured unregulated flows in the Murray River for much of winter, spring and summer. Without river regulation, Gunbower Forest would have experienced significant flooding during 2021-22. The controlled releases from storages limited flow in the Murray River at Torrumbarry Weir to a peak of 24,400 ML per day in October, which is just below the threshold of an overbank flow into Gunbower Forest.

In 2021-22, allocations against high-reliability water shares reached 52 percent in August and 100 percent in October. Low-reliability water shares began receiving allocations in December and reached their full allocations in February. This is the first

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time Murray seasonal determinations reached maximum availability since the introduction of the current entitlement products in 2007. Spills from Hume Dam resulted in the deduction of most spillable carryover from 2020-21. Section 5.2 has more information about the resource position of water for the environment in the Victorian Murray system during 2021-22.

Deliveries of water for the environment for Gunbower Creek and Forest were managed in line with an average climate scenario throughout 2021-22. All planned watering actions for 2021-22 were achieved with a combination of water for the environment, natural flow and consumptive releases. While there was no overbank flooding in Gunbower Forest in 2021-22, some high-flow water from the Murray River did enter the forest via the lower-lying floodrunners, including at Shillinglaws and Barham Cut regulators, for two weeks during October. These inflows supplemented targeted deliveries of water for the environment to selected wetlands and surrounding low-lying floodplains and improved breeding and feeding habitat for waterbirds. Several species of waterbirds (including little pied cormorants, Australasian darters and threatened musk ducks) were reported breeding at Long Lagoon, Black Swamp and Reedy Lagoon in late spring and summer. Water for the environment was also used to top up lower landscape wetlands over summer to enhance outcomes for wetland vegetation that were triggered by winter and spring watering.

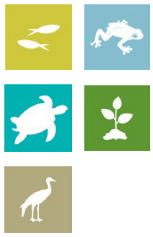
The first managed floodplain watering event in Gunbower Forest since 2018 is due to commence in June 2022. This event will be delivered via the Hipwell channel and aims to improve the condition of river red gums and their flood-dependent understorey, which require inundation events about seven out of every 10 years for optimal condition and to build their resilience to future dry periods.

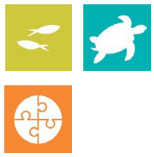
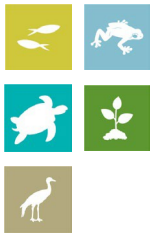
The section of Gunbower Creek downstream of Gunbower Weir had no flow between mid-May and early August 2021 — the irrigation shut-down period — to allow construction of the Koondrook and Cohuna fishways. The flow was reduced gradually to less than 20 cm drawdown per day to allow fish to migrate to deep pools, which remained over winter. Monitoring conducted during the shut-down period confirmed that populations of small-bodied fish persisted in refuge pools, and fish-trapping at the new fishways in December 2021 demonstrated that native fish are using the structures to move between the Murray River and Gunbower Creek. Additional works may occur between May and August 2022. These works may require a full drawdown of Gunbower Creek upstream of Gunbower Weir for up to two weeks, which may temporarily affect local fish populations, but the long-term benefit of the fishways is expected to significantly improve native fish outcomes for the region. The drawdown will again be gradual and closely monitored.

Scope of environmental watering

Table 5.2.7 describes the potential environmental watering actions in 2022-23, their expected watering effects (that is, the intended physical or biological effects of the watering action) and the longer-term environmental objective(s) they support. Each environmental objective relies on one or more potential environmental watering actions and their associated physical or biological effects.

Table 5.2.7 Potential environmental watering actions, expected watering effects and associated environmental objectives for Gunbower Creek and Forest

Potential environmental watering action	Expected watering effect(s)	Environmental objective(s)
Gunbower Forest		
Gunbower Forest floodplain, floodrunners and wetlands inundation (with variable flow rates during winter/spring 2022)	• Continue floodplain watering commenced in June 2022 to inundate river red gums and the flood-dependent and flood-tolerant understorey species for the optimum duration to help recover condition • Maintain the depth and extent of water in wetlands to support the growth and successful recruitment of wetland vegetation following positive outcomes in 2021-22 • Provide a variety of water depths throughout the forest to provide feeding, foraging and refuge habitat for frogs, turtles and waterbirds, including colonial nesting species and access to breeding habitat for small-bodied native fish	
Extend natural flooding in Gunbower Forest floodplain, floodrunners and wetlands (with variable flow rates to maintain an appropriate wetted extent during winter/spring 2022)	• Extend the duration and, where possible, the extent of natural floodplain and wetland inundation over the optimal growing season for aquatic vegetation • Maintain the depth and quality of water to provide habitat for small-bodied native fish, including Murray-Darling rainbowfish • Provide a variety of water depths throughout the forest to provide feeding, foraging and refuge habitat for frogs, turtles and waterbirds, including colonial nesting species	

Potential environmental watering action	Expected watering effect(s)	Environmental objective(s)
Spring fresh in Yarran Creek (variable flow rates and duration based on water levels in Gunbower Forest and flows in the Murray River and Gunbower Creek) 	• Connect Gunbower Creek and the Murray River through the Yarran Creek and Shillinglaws regulators to increase flowing habitat for the lateral movement of native fish, turtles, carbon and nutrients • Provide migration opportunities for native fish	
Black Swamp, Reedy Lagoon, Little Gunbower Creek Complex, Little Reedy Wetland Complex (top-up, variable flow rates during spring/ summer as required in response to bird breeding or significant vegetation responses) 	• Maintain adequate water levels in breeding and feeding habitats to allow breeding waterbirds to successfully fledge their chicks • Maintain adequate water levels in wetlands to extend the growth phase of wetland vegetation triggered by inundation earlier in the season	
Gunbower Forest floodplain, floodrunners and wetlands inundation (with variable flow rates during autumn/winter 2023) 	• Provide a second consecutive year of floodplain watering in 2023 to inundate river red gums and the flood-dependent and flood-tolerant understorey species for the optimum duration to help recover condition • Maintain the depth and extent of water in wetlands to support the growth and successful recruitment of wetland vegetation • Provide a variety of water depths throughout the forest to provide feeding, foraging and refuge habitat for frogs, turtles and waterbirds, including colonial nesting species and access to breeding habitat for small-bodied native fish	
Gunbower Creek (targeting Koondrook Weir)		
Year-round opportunistic fresh(es) (500 ML/day for one to four weeks, as required)	• Deliver in response to high flow in the Murray River (if conditions allow) to: • promote the exchange of carbon between Gunbower Creek and the Murray River • provide a natural migratory cue for native fish to either: - trigger the migration and spawning of native fish in the Murray River (during spring), or - attract native fish (such as golden perch and silver perch) to migrate into or to the upstream reaches of Gunbower Creek (during autumn), maximising the effect of the fishways at Koondrook and Cohuna weirs	
Autumn/winter low flow (50-200 ML/day during July to August 2022 and March to June 2023)	• At 50 ML/day: • maintain a minimum level of connectivity between Gunbower Creek and lagoons during the off-irrigation period and/or when Hipwell channel is operational • prevent sections drawing down to isolated pools At 200 ML/day: • maintain connectivity through the length of Gunbower Creek and between lagoons and fishways during the off-irrigation period to provide greater access to food resources over the cooler months, if natural inflows to Gunbower Forest are achieved	

Potential environmental watering action	Expected watering effect(s)	Environmental objective(s)
Trigger-based spring/ summer low flow (50-300 ML/day as required during September to February)	• Dilute carbon-rich water exiting Gunbower Forest at Three Corner Hole to improve water quality (oxygen concentrations) in lower Gunbower Creek if required	
Gunbower Creek (targeting Cohuna Weir)		
Spring/summer/autumn low flow (300-400 ML/ day during September to March)	• Maintain habitat and food resources for native fish and support breeding and larval survival (such as Murray cod) by minimising large variations in the water level during the irrigation season and achieving about 1.5 m depth in deeper pools and 30 cm depth in the shallow connecting littoral zone to maintain habitat. A greater area of habitat will be inundated at the upper magnitude	
Summer/autumn/winter fresh(es) flow (500 ML/ day for one to four weeks during July to August 2022 or January to June 2023, as required)	• Increase flowing habitat in Gunbower Creek to provide providing preferred hydraulic conditions for native fish	

Scenario planning

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

Gunbower Forest

The highest-priority potential watering action under all climate scenarios is to inundate the Gunbower Forest floodplain, floodrunners and wetlands via the Hipwell channel in winter/spring 2022 and winter/spring 2023. This is needed to prevent a fourth consecutive year without inundation, which would likely stress and see a drop in the condition of flood-dependent river red gums and their understorey vegetation. These vegetation communities rely on frequent inundation, and ecologists advise that flooding in consecutive years will consolidate improvements in vegetation condition and recruitment and therefore provide greater benefits than a single flood. The watering events aim to inundate about 4,500 ha (about 23 percent of the forest), which is the maximum inundation extent that can be achieved with deliveries of water for the environment. Deliveries may be modified to extend the duration or extent of any natural floods during the planned watering periods. If a second floodplain inundation event cannot be delivered in 2023, water for the environment will be used to top up selected wetlands in lower Gunbower Forest, likely in autumn, to maintain habitat for water-dependent plants and animals over autumn and winter.

There may be additional deliveries of water for the environment in Gunbower Forest in 2022-23 if particular environmental triggers are met. Water levels in selected wetlands in lower Gunbower Forest will be topped up as needed if flooding triggers a significant waterbird breeding event or notable vegetation response. If there are simultaneous high flows in the Murray River and Gunbower Creek, water for the environment may be used to deliver a spring fresh through Yarran Creek to transfer carbon and nutrients between Gunbower Creek, Gunbower Forest and the Murray River and encourage native fish to move into Gunbower Creek. Supporting fish movement through this region is important to optimise recolonisation after disturbances associated with recent fishway construction activities.

Gunbower Creek

Maintaining adequate low flow in Gunbower Creek during the irrigation shut-down period is a high priority in all years to maintain native fish communities. Channel works and reduced capacity due to the operation of the Hipwell channel are likely to limit the low-flow magnitude that can be delivered to the lower reaches of Gunbower Creek during winter 2022. The aim during this period will be to deliver sufficient water to maintain connections between deeper pools. Fish populations and water quality will be monitored during the planned works to determine whether these flows are adequate. If the monitoring identifies a significant risk to the fish populations or if the Hipwell channel is not operated at maximum capacity, flows of up to 200 ML per day will be passed downstream of Cohuna Weir.

Providing a stable flow of at least 300 ML per day over Cohuna Weir is a high priority during spring and summer under all scenarios to support Murray cod to breed and maintain habitat for small-bodied native fish. This flow may be met through a combination of consumptive releases and water for the environment. Maintaining a stable flow is less critical after the Murray cod breeding season, but a flow of about 300 ML per day will still be important between January and March to inundate the littoral zone, which provides food and cover for larval and juvenile fish.

There may be several trigger-based or opportunistic deliveries of water for the environment to Gunbower Creek under average and wet climate scenarios. These include dilution flows to mitigate against low oxygen levels (if natural floods wash significant volumes of carbon-rich water from Gunbower Forest into Gunbower Creek), as well as high flows triggered by a high flow event in the Murray River (to encourage fish movement between Gunbower Creek and the Murray River).

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It will be important to reserve water for carryover to enable high-priority actions commenced in late 2022-23 to continue into early 2023-24. About 40,000 ML of carryover is required to continue watering the Gunbower Forest floodplain, floodrunners and wetlands through to spring 2023. About 16,000 ML may be required to maintain a low flow in Gunbower Creek in 2023-24, but this could increase to 20,000 ML under a drought scenario if there is lower demand by irrigators.

Table 5.2.8 Potential environmental watering for Gunbower Creek and Forest under a range of planning scenarios

Planning scenario	Drought	Dry	Average	Wet
Expected conditions	• No natural inflow into Gunbower Forest	• No natural inflow into Gunbower Forest	• Minor natural inflow into Gunbower Forest may occur in winter/spring	• Overbank flow is likely in winter/ spring
Gunbower Forest				
Potential environmental watering – tier 1 (high priorities)[1]	• Gunbower Forest floodplain, floodrunners and wetlands inundation in winter/spring 2022 • Spring fresh in Yarran Creek • Black Swamp, Reedy Lagoon, Little Gunbower Creek Complex, Little Reedy Wetland Complex top-up in spring/summer, if required • Gunbower Forest floodplain, floodrunners and wetlands inundation in autumn/winter 2023			• Extend natural flooding in Gunbower Forest floodplain, floodrunners and wetlands in winter/ spring 2022 • Spring fresh in Yarran Creek • Black Swamp, Reedy Lagoon, Little Gunbower Creek Complex, Little Reedy Wetland Complex top-up, if required • Gunbower Forest floodplain, floodrunners and wetlands inundation in autumn/winter 2023
Potential environmental watering – tier 2 (additional priorities)	• N/A			
Gunbower Creek (targeting Koondrook Weir)				
Potential environmental watering – tier 1 (high priorities)[1]	• Autumn/winter low flow		• Autumn/winter low flow • Trigger-based spring/summer low flow, if required	
Potential environmental watering – tier 2 (additional priorities)	• N/A			• Year-round opportunistic flow
Gunbower Creek (targeting Cohuna Weir)				
Potential environmental watering – tier 1 (high priorities)[1]	• Spring/summer/autumn low flow			
Potential environmental watering – tier 2 (additional priorities)	• N/A			• Summer/autumn/ winter fresh(es)

Planning scenario	Drought	Dry	Average	Wet
Possible volume of water for the environment required to achieve objectives	• Up to 115,000 ML (tier 1)			• Up to 115,000 ML (tier 1) • 4,000 ML (tier 2)
Priority carryover requirements for 2023-24	• 60,000 ML	• 56,000 ML		

1 Tier 1 potential environmental watering at Gunbower Creek and Forest is not classified into tier 1a and 1b because the water available for use is shared across various systems, and it is not possible to reliably estimate supply.

5.2.4 Central Murray wetlands

System overview

The central Murray wetlands are located on the lower Loddon River and Murray River floodplains (Figure 5.2.3). The wetland system includes Guttrum and Benwell state forests, Hird Swamp, Johnson Swamp, Kunat Kunat (Round Lake), Lake Cullen, Lake Elizabeth, Lake Murphy, McDonalds Swamp, Muringa wetlands, Richardson's Lagoon, Third Reedy Lake and the Wirra-Lo wetland complex.

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

Eleven of the central Murray wetlands can receive water for the environment from permanent infrastructure: Hird Swamp, Johnson Swamp, Kunat Kunat, Lake Cullen, Lake Elizabeth, Lake Murphy, McDonalds Swamp, Muringa wetlands, Richardson's Lagoon, Third Reedy Lake and the Wirra-Lo wetland complex. Temporary pumps are currently used to deliver water for the environment from the Murray River to some semi-permanent wetlands in the Guttrum and Benwell forests when required. More permanent water delivery infrastructure for Guttrum and Benwell forests is proposed as part of the Victorian Murray Floodplain Restoration Project.

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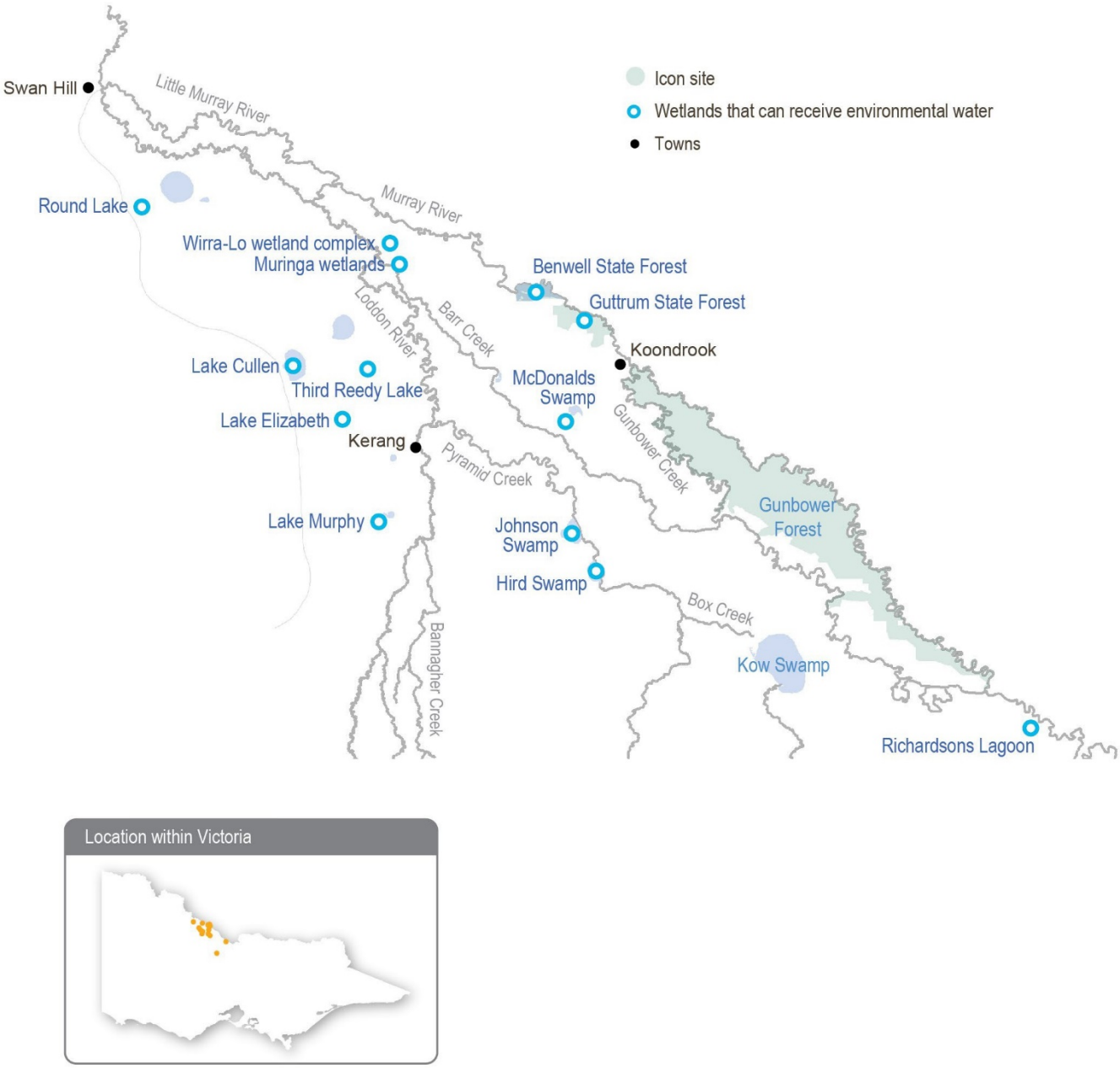
Figure 5.2.3 The central Murray wetlands



Environmental values

The central Murray wetlands support numerous listed threatened species ranging from vulnerable to critically endangered, including the Australasian bittern, Murray hardyhead, Australian painted snipe, growling grass frog and the southern purple spotted gudgeon, which was presumed extinct in Victoria until it was found at Third Reedy Lake in spring 2019. When the wetlands receive environmental water, they can attract prolific birdlife and provide feeding and breeding habitat for many threatened and endangered bird species (including the eastern great egret and white-bellied sea eagle) listed under legislation and international agreements. Lake Cullen, Hird Swamp, Third Reedy Lake and Johnson Swamp are internationally recognised under the Ramsar Convention, while the other wetlands in the central Murray system have bioregional significance.

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Environmental watering objectives in the central Murray wetlands

Icon	Environmental objectives in the central Murray wetlands
	Maintain populations of listed threatened species, including critically endangered Murray hardyhead and southern purple spotted gudgeon Maintain or increase populations of common small-bodied native fish (such as carp gudgeon and flat-headed gudgeon)
	Maintain populations of the endangered growling grass frog Maintain populations of common native frogs (such as barking marsh frog, Peron's tree frog and spotted grass frog)
	Maintain populations of native turtle species (such as Murray River turtle and the common long-necked turtle)
	Restore and then maintain the health of streamside trees (such as river red gum and black box) Restore and then maintain mudflat vegetation communities (such as tall marsh, herblands, rushes and sedges) Restore and then maintain native aquatic vegetation species (such as tassel, milfoil and pondweed) Reduce the extent and density of invasive plant species Support a mosaic of wetland plant communities across the region
	Provide resting, feeding and breeding habitat for a variety of waterbird feeding guilds, including threatened species (such as Australasian bittern, little bittern and brolga)
	Increase the diversity and biomass of waterbugs

Traditional Owner cultural values and uses

The wetlands and surrounding land in the central Murray area have rich cultural values belonging to the Traditional Owners - the Barapa Barapa, Wamba Wemba and Yorta Yorta peoples. Their traditional knowledge is a living culture evident throughout the landscape in tree markings, significant cultural sites and cultural tools for cultural practices. The rivers and floodplains are a food and fibre source and contain many sites of significance (such as camp sites and meeting places).

Environmental watering supports values such as native fish, waterbirds and turtles, and it promotes the growth of culturally important plants that provide food, medicine and weaving materials for Traditional Owner groups. The presence of water itself can be a cultural value, as well as the quality of the water: healthy water promotes a healthy Country.

Barapa Barapa and Wamba Wemba Traditional Owners have contributed to planning for water for the environment for wetlands important to them in the central Murray region in 2022-23. Focus areas include the following.

- Barapa Barapa and Wamba Wemba Traditional Owners have highlighted maintaining or improving the health of wetland vegetation as a key priority across the wetlands. Traditional Owners have raised concerns about encroachment of lignum and tall marsh at Johnson and McDonald Swamps negatively impacting wetland water flow and habitat for waterbirds. Concerns have also been raised about duck hunting at Lake Murphy and rabbits harming culturally sensitive locations.
- For 2022-23, Barapa Barapa and Wamba Wemba Traditional Owners are supportive of watering wetlands on their Country whilst allowing Lake Murphy and Hird Swamp to go through a drying phase. Barapa Barapa and Wamba Wemba Traditional Owners are interested in undertaking an Aboriginal Waterways Assessment (AWA) at several of the wetlands in the future – during wet and dry phases.
- Watering activities in Guttrum Forest will again be a particular focus for Barapa Barapa and Wamba Wemba Traditional Owners in 2022-23, as described below.

Increasing the involvement of Traditional Owners in environmental water planning and management, and ultimately providing opportunities to progress towards self-determination within environmental watering program, is a core commitment of the VEWH and its agency partners. This is reinforced by a range of legislation and policy commitments (for example the *Water Act 1989*, the Victorian Aboriginal Affairs Framework, Water for Victoria (2016)) and, in some cases, agreements under the *Traditional Owner Settlement Act 2010*. Where Traditional Owners are more deeply involved in the planning and/or delivery of environmental flows for a particular site, their contribution is acknowledged in Table 5.2.7 with an icon. The use of this icon is not intended to indicate that these activities are meeting all the needs of Traditional Owners but is incorporated in the spirit of valuing that contribution and indicating progress towards this objective.

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Watering planned and/or delivered in partnership with Traditional Owners to support cultural values and uses

Barapa Barapa and Wamba Wemba input to watering actions for Guttrum Forest in 2022-23

The proposed delivery of water for the environment to Guttrum Forest during 2022-23 has been planned in conjunction with the Barapa Barapa and Wamba Wemba peoples, for whom the wetlands and surrounding forest are places of high cultural significance. The Traditional Owners have been an important part of Guttrum Forest planning and management from the outset and were directly involved in the delivery of environmental flows to Reed Bed Swamp in 2019-20 and 2021-22.

Barapa Barapa and Wamba Wemba collaborate with waterway managers to ensure that during watering events their cultural heritage is protected and that the hydrological needs of important cultural values (such as food and medicinal plant species, scar trees and ring trees) are supported through the timing and duration of planned watering actions to the forest.

Table 5.2.7 outlines the values and uses considered in the planning for and management of water for the environment at Guttrum Forest in 2022-23.

Table 5.2.7 Barapa Barapa and Wamba Wemba cultural values and uses at Guttrum Forest

Value/use	Considerations
Food, fibre and medicinal plants	• A winter fill followed by top-ups as required will ensure that the duration of wetting will be long enough to support aquatic vegetation during its optimal growth period. Allowing the wetland to dry before summer will also promote cultural plants on the mudflats in these areas.
Cultural heritage	• Watering of Reed Bed Swamp supports fringing large old trees, including a couple of ring trees and scar trees. The condition of these trees was seen to improve following previous watering: for example, there was new growth.
Spiritual wellbeing	• The improvement in the condition of the wetland and the presence of water and moisture contribute to a sense of spiritual wellbeing.
Sharing cultural knowledge	• The Traditional Owners provide support and advice about what ecological values to target: that is, they provide information about what the wetland used to look like and what values it previously supported. • Traditional Owners have been present during the set-up of infrastructure and have been able to advise about avoiding impacts on their cultural heritage.
Employment opportunities	• Traditional Owners want to become more involved in the management of their Country through increased employment opportunities (such as ecological and cultural monitoring). This has occurred as part of previous watering of Reed Bed Swamp.
Cultural landscape	• Maintaining the open-water habitat and mudflats underneath will be difficult if the river red gum saplings that germinated in the 2016 floods are not removed. This is important for maintaining the cultural landscape and access to food and medicinal resources.
Cultural practice	• In 2019-20 when water for the environment was first delivered in Guttrum Forest, a smoking ceremony and celebration were held to welcome the water back to the wetland. The Traditional Owners have indicated that this should be a regular activity each year when water is delivered, as it is something that their ancestors would have done when the floodwaters arrived and would represent a restoration of an important cultural practice. • Another priority in 2022-23 is to provide more opportunities for women to return to Country and undertake cultural practices such as weaving, emu egg carving and discussion of the wetlands' health as it relates to women's business.

Social, recreational and economic values and uses

In planning the potential watering actions in Table 5.2.10, North Central CMA considered how environmental flows could support values and uses, including:

- waterway recreation (such as canoeing, fishing, kayaking, swimming and water sports)
- waterway recreation and amenity (such as birdwatching, duck hunting, camping, cycling, running and walking)
- community events and tourism (such as visitation during the hunting and fishing seasons, Breakfast with the Birds events [hosted annually by North Central CMA] and supporting Aboriginal cultural heritage and history-based tours)
- socio-economic benefits (such as ecosystem services like groundwater recharge, flood mitigation, nutrient treatment, carbon storage and stock and domestic uses).

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Recent conditions

Rainfall across the central Murray wetlands (as recorded at Kerang) was close to the long-term average in 2021-22, but it varied considerably between months. December 2021 and February 2022 recorded the lowest rainfall, whereas January and April exceeded the long-term average significantly. Temperatures remained close to the long-term average and did not vary greatly. Deliveries of water for the environment at central Murray wetlands are made from Murray environmental entitlements.

In 2021-22, allocations against high-reliability water shares reached 52 percent in August and 100 percent in October. Low-reliability water shares began receiving allocations in December and reached their full allocations in February. This is the first time Murray seasonal determinations reached maximum availability since the introduction of the current entitlement products in 2007. Spills from Hume Dam resulted in the deduction of most spillable carryover from 2020-21. Section 5.2 has more information about the resource position of water for the environment in the Victorian Murray system during 2021-22.

Deliveries of water for the environment for the Central Murray wetlands were managed in line with an average climate scenario during 2021-22, and nearly all planned deliveries were achieved.

Richardson's Lagoon and Reed Bed Swamp in Guttrum Forest were filled in late winter/early spring and they received additional top-up deliveries in spring/early summer. Water levels at Richardson's Lagoon inundated both river red gum and black box trees on higher ground and provided a mosaic of habitats. Vulnerable musk duck and turtles were observed breeding at Richardson's Lagoon, although some of the turtle nests were raided by foxes. Reed Bed Swamp held water until February before drawing down, and swathes of the threatened river swamp wallaby grass, wavy marshwort and water nymph responded well.

Kunat Kunat and Lake Elizabeth were filled in spring 2021 and topped up in autumn 2022 to maintain water levels, salinity and habitat conditions for Murray hardyhead. The two Muringa wetlands and six wetlands within the Wirra-lo wetland complex were also watered in spring and topped up over summer and autumn to support growling grass frogs, waterbirds and wetland vegetation communities. Lake Murphy was filled in spring to support vegetation communities, including recently planted river red gums. It was allowed to partially draw down over summer to provide foraging habitat for migratory waterbirds and then topped up again in autumn to optimise the survival of recently planted trees and fringing wetland plants.

Both McDonalds Swamp and Johnson Swamp received a partial fill over late autumn/winter to drown terrestrial weeds and promote aquatic vegetation and habitat for waterbirds, frogs and turtles.

Third Reedy Lake, Hird Swamp and Lake Cullen were all allowed to draw down during 2021-22 to support important dry-cycle wetland processes (such as nutrient cycling and the growth of lake-bed herbland plants). Periodic drying in Hird Swamp is particularly important to help control the encroachment of tall marsh and ensure adequate open-water habitat when it is next filled. Unauthorised tampering of a regulator delivered water to Lake Cullen on several occasions during 2021-22, but the volumes delivered were not significant and did not adversely affect the growing herbland vegetation.

The only planned watering actions not delivered during 2021-22 were a partial fill at Guttrum Forest in autumn/winter 2022 and spring fills at Lignum Swamp North and Red Gum Swamp in the Wirra-lo wetland complex. Guttrum Forest had two planned watering actions for 2021-22, and temporary pumping at the site at the time required significant planning and administrative approvals. The winter/spring fill went ahead as planned, but the need for the autumn partial fill often depends on the level of the drawdown, which is not known until near the end of summer. There was insufficient time for North Central CMA to complete the required approvals for the action to proceed. Recent changes to approval requirements may overcome this issue for future watering events, and delivery will further be streamlined once permanent water delivery infrastructure is constructed at the site, as proposed under the Victorian Floodplain Murray Restoration Project. Watering of Lignum Swamp North and Red Gum Swamp could not proceed due to administrative approvals that were needed for development works to mitigate current delivery constraints.

Scope of environmental watering

Table 5.2.10 describes the potential environmental watering actionsflows in 2022-23, their expected watering effects (that is, the intended physical or biological effects of the watering action) and the longer-term environmental objectives they support. Each environmental objective relies on one or more potential environmental watering actions and their associated physical or biological effects.

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Table 5.2.10 Potential environmental watering actions, expected watering effects and associated environmental objectives for the central Murray wetlands

Potential environmental watering action	Expected watering effects	Environmental objectives
Guttrum Forest (fill in winter/spring and further top-ups as required in spring/summer)	• Wet the fringing adult river red gums to support their growth and drown river red gum saplings within the wetland bed to maintain open-water habitat • Promote the growth and re-establishment of aquatic vegetation and tall marsh vegetation at the fringe of the wetland • Maintain the depth of the wetland to support frogs and waterbird feeding and breeding	
Guttrum Forest (partial fill in autumn/winter 2023)	• Inundate existing adult river red gums to support their growth, and drown river red gum saplings in the open-water habitat • Increase the water depth and extent to trigger wetland plants to germinate in late winter and when follow-up watering is provided in early spring 2023 • Provide feeding and refuge habitat for waterbirds and frogs	
Johnson Swamp (fill in winter/spring and top up as required)	• Drown terrestrial weeds to limit their growth and reduce their extent • Promote the germination and establishment of aquatic vegetation • Inundate the wetland fringe to provide habitat for waterbirds, frogs and turtles and provide conditions suitable for macroinvertebrates and small-bodied native fish that are food for waterbirds	
Johnson Swamp (throughflow in spring/ summer)	• Provide connectivity between Johnson Swamp and Pyramid Creek to boost productivity, support macroinvertebrates and support nutrient cycling inputs for the creek and food resources for fish • Flush carbon and biofilms within the wetland to promote new growth and increase waterbug activity for native fish	
Kunat Kunat (fill in spring, top up as required)	• Maintain salinity within 15,000-80,000 EC and the water depth to support suitable habitat and breeding conditions for Murray hardyhead and growing conditions for submerged aquatic plants that provide habitat for Murray hardyhead • Maintain the water depth to provide permanent feeding, foraging and refuge habitat for waterbirds	
Lake Cullen (partial fill in winter/spring, top up as required)	• Provide feeding, breeding and refuge habitat for waterbirds • Inundate the wetland to provide feeding and breeding for waterbirds and suitable conditions for macroinvertebrates and submerged plants as food resources for waterbirds	
Lake Elizabeth (fill in spring, top up as required)	• Maintain salinity within 15,000-80,000 EC and the water depth to support suitable habitat and breeding conditions for Murray hardyhead and growing conditions for submerged aquatic plants that provide habitat for Murray hardyhead • Maintain the water depth to provide permanent feeding, foraging and refuge habitat for waterbirds	
McDonalds Swamp (fill in winter/spring, top up as required)	• Drown terrestrial weeds to limit their growth and reduce their extent • Promote the germination and establishment of aquatic vegetation • Inundate the wetland body and fringe to provide habitat for waterbirds, frogs and turtles and provide conditions suitable for macroinvertebrates that are food for waterbirds, frogs and turtles • Support the growth of planted river red gums and other aquatic and herbland vegetation • Wet the fringing river red gums to support their growth	

Potential environmental watering action	Expected watering effects	Environmental objectives
Muringa wetlands (fill in winter/spring, top up as required)	• Support the growth of aquatic and semi-aquatic plants • Increase the area of habitat and grow zooplankton and waterbug communities to provide food resources for frogs and waterbirds	
Richardson's Lagoon (fill in late winter/spring)	• Maintain the water level to support the condition of aquatic macrophytes and aquatic reeds and rushes (i.e. tall marsh) around the deep lagoon channels and wetland fringes • Increase the extent of floodplain inundation to support the growth of floodplain red gums and promote the germination and establishment of flood-dependant understory vegetation • Support the growth of traditional plant species at a significant cultural site enabling the continuation of cultural practices (e.g. harvesting, medicine and weaving) • Provide a diversity of water depths to provide feeding, foraging and refuge habitat for water-dependent animals, including waterbirds, turtles and frogs	
Wirra-Lo wetland complex: Bunyip Swamp East and Bunyip Swamp West (fill in winter/spring, top up as required)	• Inundate recently established reed beds to stimulate their growth to create feeding and nesting habitat for Australasian bittern	
Wirra-Lo wetland complex: Cattleyard Creek (fill in winter/spring, top up as required)	• Inundate river red gum woodland trees to promote their growth and improve their condition • Promote the germination and establishment of aquatic vegetation • Inundate habitat to provide feeding and breeding opportunities for frogs and waterbirds	
Wirra-Lo wetland complex: Duck Creek North (fill in winter/spring, top up as required)	• Improve soil moisture in the wetland fringe to promote the recruitment and increase the extent of river red gum trees • Inundate the aquatic and herbland vegetation to promote its growth and increase its extent • Maintain open-water and associated mudflat habitats for waterbirds to feed and breed	
Wirra-Lo Wetland complex: Emu Creek (fill in winter/spring, top up as required)	• Inundate black box and lignum along the creekline to improve their condition • Promote the germination and growth of aquatic vegetation in the deeper sections of the wetland to support frogs and freshwater turtles • Provide soil moisture along the perimeter to maintain the condition of trees for terrestrial fauna, including resident grey crowned babblers	
Wirra-Lo wetland complex: Lignum Swamp North (fill in winter/spring, top up as required)	• Promote the establishment and growth of submerged and emergent aquatic vegetation to provide feeding and breeding habitat for growling grass frogs • Inundate habitat to provide feeding and breeding opportunities for frogs, waterbirds and turtles	
Wirra-Lo wetland complex: Lignum Swamp South (fill in winter/spring, top up as required)	• Inundate recently established reed beds to stimulate their growth to create feeding and nesting habitat for Australasian bittern • Promote the establishment and growth of submerged and emergent aquatic vegetation to provide feeding and breeding habitat for growling grass frogs • Inundate habitat to provide feeding and breeding opportunities for frogs, waterbirds and turtles	

Potential environmental watering action	Expected watering effects	Environmental objectives
Wirra-Lo wetland complex: Red Gum Swamp (fill in winter/ spring, top up as required)	• Inundate established river red gum trees to promote their growth and maintain their condition • Inundate habitat to provide feeding and breeding opportunities for frogs, waterbirds and turtles	

Scenario planning

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

North Central CMA has developed a wetland strategy that aims to manage combinations of wetlands at a landscape scale to address particular environmental objectives. In applying the criteria described in the strategy, North Central CMA has prioritised potential watering actions for 14 wetlands across the central Murray for watering under all climatic scenarios. These include Guttrum Forest, Johnson Swamp, Kunat Kunat, Lake Cullen, Lake Elizabeth, Muringa wetlands and Wirra-lo wetlands complex: Bunyip Swamp East and West, Cattleyard Creek, Duck Creek North, Emu Creek, Lignum Swamp North and South and Red Gum Swamp. Under dry to wet climatic scenarios, McDonalds Swamp and Richardson's Lagoon also become a high priority.

Watering actions proposed for Kunat Kunat and Lake Elizabeth are needed to maintain permanent habitat for endangered species like the Murray hardyhead. Sites within the Wirra-lo wetland complex also require water under all scenarios to support endangered species (such as Australasian bittern and growling grass frog) and to maintain red gum and black box communities. Muringa wetlands have recently been added to the environmental watering program, and they were actively watered for the first time in 2021-22. Follow-up watering is considered a high priority in 2022-23 to help planted vegetation communities become established and consolidate the benefits of last year's watering.

Johnson Swamp, Lake Cullen, McDonalds Swamp and Richardson's Lagoon are all ephemeral wetlands that are due to commence or complete their planned wet phase in 2022-23. Johnson Swamp completely dried in December 2020 and received a partial fill in autumn 2022 to prime it for the planned fill in winter/spring 2022. Inundating previously dried parts of the wetland is expected to trigger a significant productivity boost, so some water will be passed through the wetland and outfall to Pyramid Creek to supply zooplankton, macroinvertebrates and nutrients to stimulate foodwebs in the creek. Lake Cullen has been dry since 2020-21, and it needs water in 2022-23 to trigger the growth of aquatic plants and provide feeding and breeding opportunities for frogs, birds and turtles while other wetlands in the region enter their dry phase.

McDonalds Swamp and Richardson's Lagoon received water for the environment in 2021-22, and they need follow-up watering in 2022-23 to achieve the optimal watering regime for their vegetation communities and consolidate the environmental benefits of last year's watering. Filling these wetlands in winter and spring will enhance the growth and recruitment of wetland plants and fringing trees and provide feeding and breeding opportunities for waterbirds, frogs and turtles. Watering McDonalds Swamp and Richardson's Lagoon is a lower priority under a drought scenario because watering in 2021-22 partially met many of the vegetation objectives for each site and because waterbirds, frogs and turtles will be unlikely to breed.

In Guttrum Forest, a fill in winter/spring, with top-ups over spring/summer, is planned to maintain the water level and build on environmental outcomes achieved in 2021-22, including supporting recent revegetation works and regeneration at Reed Bed Swamp. A fill may be delivered in autumn/winter 2023 at Guttrum Forest if relevant approvals can be obtained in time. The decision to deliver water in autumn/winter will depend on Traditional Owner and ecological assessments in early 2023 and the level of the drawdown over summer, as well as forecast water availability and carryover for 2023-24. Under a wet climate scenario, overbank flows are likely to fill the wetland naturally in autumn/winter 2023.

Lake Murphy, Third Reedy Lake and Hird Swamp will not receive water for the environment in 2022-23 to support essential dry-phase ecosystem processes in line with recommendations in their management plans.

Priority carryover for 2023-24 of 4,600 ML is essential to maintain water at sites for endangered fish and frogs and to provide a mosaic of refuge wetlands across the region in the event of dry or drought conditions.

Table 5.2.11 Potential environmental watering for the central Murray wetlands under a range of planning scenarios

Planning scenario	Drought	Dry	Average	Wet
Expected conditions	• Catchment run-off and natural flow into the wetlands are highly unlikely	• Catchment run-off and natural flow into the wetlands are unlikely	• Low-to-moderate catchment run-off and natural flow into the wetlands are possible, particularly in winter/spring	• Catchment run-off and natural flow into the wetlands is likely, with potential flooding in some wetlands, particularly in winter/spring

<table>
<tr><th>Planning scenario</th><th>Drought</th><th>Dry</th><th>Average</th><th>Wet</th></tr>
<tr><td>Potential environmental watering – tier 1 (high priorities)</td><td>• Guttrum Forest (winter/spring)
• Guttrum Forest (autumn/winter 2023)[1]
• Kunat Kunat (Round Lake)
• Lake Elizabeth
• Wirra-lo Wetland complex (Bunyip Swamp East, Bunyip Swamp West, Cattleyard Creek, Duck Creek North, Emu Creek, Lignum Swamp North and South, Red Gum Swamp)
• Muringa Wetlands
• Lake Cullen
• Johnson Swamp</td><td>• Guttrum Forest (winter/spring)
• Guttrum Forest (autumn/winter 2023)[1]
• Kunat Kunat (Round Lake)
• Lake Elizabeth
• Wirra-lo Wetland complex (Bunyip Swamp East, Bunyip Swamp West, Cattleyard Creek, Duck Creek North, Emu Creek, Lignum Swamp North and South, Red Gum Swamp)
• Muringa Wetlands
• Lake Cullen
• Johnson Swamp
• Johnson Swamp throughflow
• McDonalds Swamp
• Richardson's Lagoon</td><td>• Guttrum Forest (winter/spring)
• Guttrum Forest (autumn/winter 2023)[1]
• Kunat Kunat (Round Lake)
• Lake Elizabeth
• Wirra-lo Wetland complex (Bunyip Swamp East, Bunyip Swamp West, Cattleyard Creek, Duck Creek North, Emu Creek, Lignum Swamp North and South, Red Gum Swamp)
• Muringa Wetlands
• Lake Cullen
• Johnson Swamp
• Johnson Swamp throughflow
• McDonalds Swamp
• Richardson's Lagoon</td><td>• Guttrum Forest (winter/spring)
• Guttrum Forest (autumn/winter 2023)[1]
• Kunat Kunat (Round Lake)
• Lake Elizabeth
• Wirra-lo Wetland complex (Bunyip Swamp East, Bunyip Swamp West, Cattleyard Creek, Duck Creek North, Emu Creek, Lignum Swamp North and South, Red Gum Swamp)
• Muringa Wetlands
• Lake Cullen
• Johnson Swamp
• Johnson Swamp throughflow
• McDonalds Swamp
• Richardson's Lagoon</td></tr>
<tr><td>Potential environmental watering – tier 2 (additional priorities)</td><td>• McDonalds Swamp
• Richardson's Lagoon</td><td colspan="3">• N/A</td></tr>
<tr><td>Possible volume of water for the environment required to achieve objectives</td><td>• 15,160 ML (tier 1)
• 2,450 ML (tier 2)</td><td>• 16,750 ML (tier 1)</td><td>• 16,650 (tier 1)</td><td>• 16,250 (tier 1)</td></tr>
<tr><td>Priority carryover requirements for 2023-24</td><td colspan="4">• 4,600 ML</td></tr>
</table>

1 Where it can be delivered within licence approval requirements.

5.2.5 Hattah Lakes

System overview

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

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

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

The Messenger, Oateys and Cantala regulators allow water to flow between the Murray River and the Hattah Lakes. When flows in the Murray River are about 26,000 ML per day, water begins to flow through Messengers regulator into Chalka Creek and through to the Hattah Lakes complex. A permanent pump station can deliver up to 1,000 ML per day to the southern Hattah Lakes through Chalka Creek. The regulators and pump station are used in combination with several small constructed

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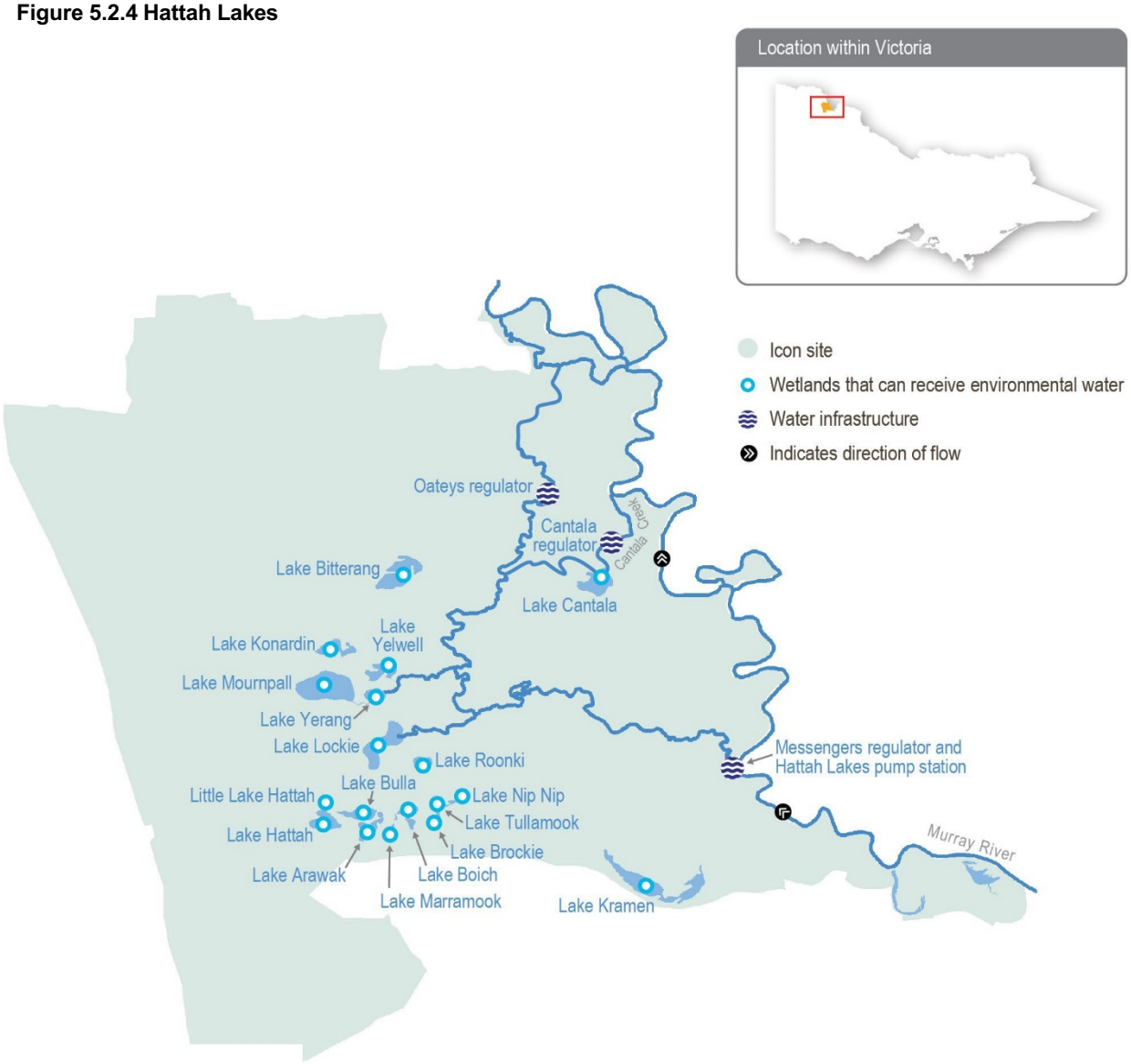
levees to restore a beneficial pattern of flooding to the lakes system. Lake Kramen is in the south-east area of Hattah-Kulkyne National Park and is disconnected from the main Hattah Lakes complex. The Hattah Lakes pump station can deliver up to 145 ML per day to Lake Kramen. The new infrastructure being built under the Victorian Murray Floodplain Restoration Project (VMFRP) will allow water to reach additional wetlands and floodplain areas in the northern Hattah Lakes.

Figure 5.2.4 Hattah Lakes



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Environmental values

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

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

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

The Hattah Lakes support large-bodied native fish species (such as golden perch) and small-bodied wetland species (such as carp gudgeon). Fish move between the lakes and the Murray River when flows are suitable and also persist in wetlands that retain water in the Hattah Lakes during dry years before dispersing again during flooding.

Environmental watering objectives in the Hattah Lakes

Icon	Environmental objectives in the Hattah Lakes[1]
	Maintain populations of small-bodied and large-bodied native fish at the Hattah Lakes
	By 2030, improve the function of water-dependent ecosystems by improving productivity linkages between the river and floodplain/wetland habitats
	Improve the species richness and abundance of native water-dependent floodplain and wetland aquatic vegetation by 2030 Maintain the extent and improve the condition of river red gum, black box and lignum, compared to 2006 baseline levels by 2030
	Maintain and/or increase the regional waterbird population by providing conditions for breeding and fledging at least three times every 10 years Maintain and/or increase the regional waterbird population by providing refuge during droughts
	Maintain a variety of freshwater ecosystem types within the Hattah Lakes Icon Site, including semi-permanent lakes, persistent temporary wetlands, floodplain woodlands, shrublands and episodic wetlands

1 All objectives are derived from the Mallee CMA's 2021 *Hattah Lakes Environmental Watering Management Plan*, and they generally include targets for improving environmental values to be achieved by 2030. Objectives for maintaining the condition of environmental values are not time-bound and should be achieved each year continuously until 2030 and beyond.

Traditional Owner cultural values and uses

The Hattah Lakes system is part of a highly sensitive region for Aboriginal cultural values and lies on the border of two documented language groups, the Latji Latji and the Jari Jari. Groups which have an interest in Hattah Lakes include Latji Latji Mumthelang, Tati Tati, Culpra-Millee, Nyeri Nyeri and Munatunga Elders.

More than 1,000 Aboriginal archaeological sites at the Hattah Lakes are registered with Aboriginal Victoria, with the freshwater lakes and wetlands providing focal points for trade and cultural exchanges among the region's Traditional Owners. Local Aboriginal communities maintain strong connections to the land and its resources, such as native species used for food and medicine.

Although COVID-19 restrictions limited opportunities for large on-Country meetings, several face-to-face meetings were held in early 2022 to discuss plans for water for the environment in the Hattah Lakes area. Mallee CMA met with Latji Latji Mumthelang and representatives from Munatunga and Culpra Millee. Traditional Owner groups invited to discussions included Tati Tati and Nyeri Nyeri.

Tati Tati wish to express their lack of representation in no way is a reflection their lack of interest or cultural responsibility in caring for wetlands on Tati Tati Country. It does, however, reflect Tati Tati's deliberate shift to only engaging organisations that demonstrate a commitment to upholding cultural safety. Tati Tati will continue to look to the future to partner with organisations transitioning to First Nations empowerment – not engagement.

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Discussions covered the planning of water for the environment and interests and aspirations for the Hattah Lakes region. Themes raised during discussions included:

- areas where environmental flows are planned to take place in 2022-23 and the quantity of water that will be delivered
- areas that Aboriginal Elders and other participants believe require water (such as Chalka Creek, as it is very dry in this area, and Lake Kramen, although historically this lake has dried out temporarily)
- projects underway that include constructing a levee to allow water to be delivered into the floodplain north of the current area of delivery as part of the VMFRP.

Social, recreational and economic values and uses

In planning the potential watering actions in Table 5.2.12, Mallee CMA considered how environmental flows could support values and uses, including:

- water-based recreation (such as fishing, kayaking and swimming)
- riverside recreation and amenity (such as birdwatching, camping, photography and walking)
- community events and tourism (such as 'Junior Ranger' school holiday programs run by Parks Victoria, including bushwalking, birdwatching and bug hunting; local school education programs; Melbourne-based schools' educational excursions; and tours involving kayaking, bike riding and camping)
- socio-economic benefits (such as commercial beekeepers who rest bees away from horticultural orchards in native flowering trees around the lake, multiple ecotourism operators who benefit directly when the lakes contain water, social wellbeing from connecting with nature, and social gatherings).

Recent conditions

Between July 2021 and March 2022, the temperature and rainfall in the vicinity of the Hattah Lakes were above average.

In 2021-22, allocations against high-reliability water shares reached 52 percent in August and 100 percent in October. Low-reliability water shares began receiving allocations in December and reached their full allocations in February. This is the first time Murray seasonal determinations reached maximum availability since the introduction of the current entitlement products in 2007. Spills from Hume Dam resulted in the deduction of most spillable carryover from 2020-21. Section 5.2 has more information about the resource position of water for the environment in the Victorian Murray system during 2021-22.

While the Hattah Lakes can receive minor inflows after heavy local rainfall, the hydrology is mainly affected by large flows in the Murray River that spill into the lakes and by deliveries of water for the environment.

The southern Hattah Lakes were partially filled with water for the environment in May and June 2021 after a two-year drying period. Unregulated flows in the Murray River in October and November 2021 exceeded the minimum commence-to-flow level into the Hattah Lakes, but they were lower than the water levels in the lakes at the time. The regulators in Chalka Creek were kept closed to prevent existing water from flowing out of the lakes, and the Hattah pumps were used to deliver some of the Murray River flows into the lakes.

Deliveries of water for the environment for the Hattah Lakes were managed in line with an average climate scenario during 2021-22, and all the planned actions were fully achieved. The lakes are only managed in line with a wet climate scenario in years when the Murray River floods and causes widespread inundation of the Hattah Lakes system.

More than 46,000 ML of water for the environment was delivered to the southern Hattah Lakes during October and November 2021, inundating 17 lakes and low-lying parts of the surrounding floodplain. Water levels drew down over summer and autumn through a combination of active releases, seepage and evaporation. About 15,000 ML of water for the environment drained from the Hattah Lakes back into the Murray River from December 2021 to March 2022, carrying carbon, nutrients and organisms that can support riverine food webs. Water that returned to the Murray River was subsequently used for environmental flows at downstream sites in South Australia.

Lake Kramen is a periodically inundated (episodic) wetland, separate from the main Hattah Lakes, that requires filling on average once every eight years. It last filled in 2019 and dried during 2021-22. No active watering is planned at Lake Kramen for at least four years to allow lake-bed herbaceous plants to grow and complete their life cycles.

The influence of La Niña (although weakening) remained steady over south-eastern Australia during autumn 2022 and continues to influence the climate outlook. This climate feature, combined with the prospect of high water availability in 2022-23, may trigger additional deliveries of water for the environment in 2022-23 to build on environmental outcomes achieved in 2021-22.

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Scope of environmental watering

Table 5.2.12 describes the potential environmental watering actions in 2022-23, their expected watering effects (that is, the intended physical or biological effects of the watering action) and the longer-term environmental objectives they support. Each environmental objective relies on one or more potential environmental watering actions and their associated physical or biological effects.

Table 5.2.12 Potential environmental watering actions, expected watering effects and associated environmental objectives for the Hattah Lakes

Potential environmental watering action[1]	Expected watering effects	Environmental objectives
Southern Hattah Lakes (top up and fill selected wetlands between 42.5 m and 43.5 m AHD and lower floodplain during winter/spring 2022)	• Stimulate the growth and improve the condition of river red gums fringing wetlands and (when filled to 43.5 m AHD) on the lower floodplain • Provide conditions for lake-bed herbaceous plants to grow during the drawdown phase following watering • Provide breeding and feeding habitat for waterbirds • Stimulate new growth of aquatic vegetation • Inundate dry wetlands to release carbon and nutrients to increase food web productivity • Increase productivity in the Murray River downstream of the Hattah Lakes through the provision of return flows (when filled to 43.5 m AHD) • Provide connections between the floodplain and the Murray River to allow the exchange of nutrients, carbon, fish and plant propagules • Provide spawning and recruitment habitat for small-bodied native fish and nursery habitat for large-bodied native fish (such as golden perch) • Inundate a variety of wetland types at different elevations across the Hattah Lakes to increase habitat diversity	
Southern Hattah Lakes (top up and fill selected wetlands and lower floodplain to 43.5 m AHD at any time following a natural flood)		

1 In consultation with the VEWH, Mallee CMA and Parks Victoria, the Hattah Lakes pump station may be operated at any time of year by Goulburn-Murray Water for testing, pump maintenance and repairs.

Scenario planning

Table 5.2.13 outlines potential environmental watering and expected water use under a range of planning scenarios.

In 2022-23, deliveries of water for the environment are planned for the Hattah Lakes under all climate scenarios except for drought.

Under a wet climate scenario, natural floods are expected to inundate large parts of the Hattah Lakes. If only minor or moderate flooding occurs, water for the environment may be pumped into the lakes to achieve the target water level of 43.5 m AHD to inundate floodplain habitats.

In the absence of a natural flood in winter or early spring, the Hattah pumps will be used to refill the lakes and low-lying areas of the floodplain that were watered in autumn and spring of 2021. The proposed delivery of 35,000 ML of water for the environment under an average scenario (providing inundation to 43.5 m AHD) will provide consecutive years of high-level inundation of the Hattah Lakes to consolidate and build on environmental outcomes from watering in 2021-22.

The level of watering will likely vary between a dry and average climate scenario to mimic natural variations in water levels associated with each scenario. Up to 15,000 ML of water for the environment will be delivered under a dry climate scenario to top up the semi-permanent wetlands within the southern Hattah Lakes system to 42.5 m AHD. Up to 35,000 ML will potentially be delivered under an average climate scenario to inundate semi-permanent wetlands in low-lying areas as well as some temporary wetlands at slightly higher elevations.

No active watering is proposed under a drought scenario. The water delivered to the Hattah Lakes in spring 2021 will likely persist in some wetlands throughout 2022-23 without additional water, and it will provide refuge habitat for waterbirds and fish that moved into the Hattah Lakes during the deliveries in 2021. There is little value in trying to deliver extra water to trigger plant and animal growth and reproduction during drought conditions because there may not be sufficient resources within the landscape to sustain new life.

It is envisaged that during 2023-24, Hattah Lakes will enter a drawdown phase, and there is currently no requirement for high-priority carryover under any climate scenario.

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Table 5.2.13 Potential environmental watering for the Hattah Lakes under a range of planning scenarios

Planning scenario	Drought	Dry	Average	Wet
Expected river conditions	• Low flow year-round in the Murray River and no natural inflow to the Hattah Lakes; substantial wetland drying will occur	• Rare high-flow events in the Murray River and no natural inflow to the Hattah Lakes	• Short periods of high flow in the Murray River with minor spills from storages, most likely in late winter/ spring, providing minor natural inflow to the Hattah Lakes	• Lengthy periods of high flow in the Murray River with major spills from storages resulting in widespread wetting of the Hattah Lakes and floodplain
Potential environmental watering – tier 1 (high priorities)	• N/A	• Southern Hattah Lakes spring top up and fill to 42.5 m AHD targeting semi-permanent[1] wetlands	• Southern Hattah Lakes spring top up and fill to 43.5 m AHD targeting semi-permanent[1] wetlands, temporary[2] wetlands and low-level floodplain inundation	• Southern Hattah Lakes top up and fill to 43.5 m AHD at any time targeting semi-permanent[1] wetlands, temporary[2] wetlands and low-level floodplain inundation
Possible volume of water for the environment required to achieve objectives	• N/A	• 15,000 ML	• 35,000 ML	• 0-35,000 ML
Priority carryover requirements for 2023-24	• No priority carryover requirements for 2023-24			

1 Lakes Bulla, Hattah, Little Hattah, Lockie, Mournpall and Yerang.
2 Lakes Arawak, Boich, Bitterang, Brockie, Cantala, Konardin, Nip Nip, Roonki, Tullamook, Woterap and Yelwell.

5.2.6 Lower Murray wetlands

System overview

The lower Murray wetlands are dispersed across the Murray River floodplain between Swan Hill and the South Australian border. The system includes a myriad of interconnected creeks, wetlands and floodplains that are ecologically important and reflect the natural character and attributes of the floodplain. While the number of wetlands across the lower Murray region is in the hundreds, about 54 of these have received water for the environment to date.

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

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

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Figure 5.2.5 The lower Murray wetlands

Environmental values

Environmental watering objectives in the lower Murray wetlands

Icon	Environmental objectives in the lower Murray wetlands
	Promote carbon and nutrient cycling to enable wetland processes for food webs
	Maintain and/or increase populations of native fish in permanent wetlands
	Maintain and/or grow populations of native frogs, including the endangered growling grass frog
	Increase the diversity, extent and abundance of wetland plants Improve the condition of river red gums, black box and lignum communities
	Provide feeding and breeding habitat for a range of waterbird species, including threatened and migratory species and colonial nesting species (such as egrets)

Traditional Owner cultural values and uses

Watering of the lower Murray wetlands supports cultural values such as traditional food sources and medicines and important species, and it provides opportunities for teaching, learning and storytelling.

On proposed 2022-23 watering of the lower Murray wetlands, Mallee CMA engaged with the First People of the Millewa-Mallee Aboriginal Corporation (FPMMAC) comprised of Latji Latji and Ngintait Traditional Owners (Traditional Owners from Hattah to the South Australian border). Mallee CMA also engaged with Latji Latji Mumthelang and representatives from Culpra Millee and Munatunga.

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Traditional Owner groups invited to discussions included Tati Tati, Wamba Wemba, Wadi Wadi, Weki Weki and Nyeri Nyeri.

Tati Tati wish to express their lack of representation in no way is a reflection their lack of interest or cultural responsibility in caring for wetlands on Tati Tati Country. It does, however, reflect Tati Tati's deliberate shift to only engaging organisations that demonstrate a commitment to upholding cultural safety. Tati Tati will continue to look to the future to partner with organisations transitioning to First Nations empowerment – not engagement.

Discussions covered a range of options for how environmental flows could be delivered in 2022-2023 and what the traditional ecological needs are in the current climate. Discussions also covered how the planning process works, as some community members had not participated in previous years. The values, knowledge and concerns identified in these discussions have supported the Mallee CMA's planning for wetland watering across the lower Murray region.

Elders from the Nyah Floodplain region (Culpra Millee) said that watering creeks across the floodplain is good for their communities, enabling many generations to get out on Country while water is in the creeks. They said they would like to be involved in planning for water for the environment from the start and all the way through: from before water is pumped to when water flows in the creeks. Opportunities to foster intergenerational education and the passing down of cultural knowledge are also very important.

Increasing the involvement of Traditional Owners in the planning and management of water for the environment and ultimately providing opportunities to progress towards self-determination within the environmental watering program is a core commitment of the VEWH and its agency partners. This is reinforced by a range of legislative and policy commitments, including the *Water Act 1989*, the Victorian Aboriginal Affairs Framework, the 2016 *Water for Victoria* and in some cases, agreements under the *Traditional Owner Settlement Act 2010*.

Where Traditional Owners are more deeply involved in the planning and/or delivery of environmental flows for a particular site, their contribution is acknowledged in Table 5.2.14 with an icon. The use of this icon is not intended to indicate that these activities are meeting all the needs of Traditional Owners but is incorporated in the spirit of valuing their contribution and indicating progress towards deeper involvement.

Watering planned and/or delivered in partnership with Traditional Owners to support cultural values and uses

Robertson Creek is an area of high cultural significance that is being degraded as drying vegetation dies and wind erodes the landscape. The First People of the Millewa-Mallee Aboriginal Corporation is undertaking a program of restoration and protection work at the site. An environmental flow was delivered to the creek in spring 2020-21 and again in 2021-22 to complement the restoration and protection objectives. This has helped improve the condition of trees and shrubs and helped return and protect cultural values which are important for community learning, teaching and overall wellbeing. An environmental flow is planned for Robertson Creek in 2022-23 in all scenarios except drought. This will build on outcomes from previous watering by further improving the condition of the vegetation and increasing protection against wind. It will also support the revegetation of native trees, shrubs and grasses.

Social, recreational and economic values and uses

In planning the potential watering actions in Table 5.2.14, Mallee CMA considered how environmental flows could support values and uses, including:

- water-based recreation (such as canoeing, fishing and kayaking)
- riverside recreation and amenity (such as bike riding, birdwatching, bushwalking, camping, geocaching, photography and running)
- community events and tourism (such as day trips and sightseeing; education programs for school, TAFE and university students; citizen science projects about birds, frogs and bats; and sporting events)
- socio-economic benefits (such as economic benefits for businesses in the accommodation, beekeeping, food and beverage, ecotourism, hospitality and retail sectors; creating a focal point for socialising; and providing natural, green spaces for the local community).

Recent conditions

Rainfall across the lower Murray floodplain in 2021-22 was close to or slightly above the long-term average. Rainfall in the upper Murray and Murrumbidgee catchments was significantly greater than average, and it delivered sustained periods of unregulated flow in the Murray River. Increased flow in the Murray River during spring and early summer naturally inundated some of the low-lying wetlands on the lower Murray floodplain.

In 2021-22, allocations against high-reliability water shares reached 52 percent in August and 100 percent in October. Low-reliability water shares began receiving allocations in December and reached their full allocations in February. This is the first time Murray seasonal determinations reached maximum availability since the introduction of the current entitlement products in 2007. Spills from Hume Dam resulted in the deduction of most spillable carryover from 2020-21. Section 5.2 has more information about the resource position of water for the environment in the Victorian Murray system during 2021-22.

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Deliveries of water for the environment for the Lower Murray wetlands were managed in line with a dry climate scenario at the start of 2021-22 but shifted to an average scenario in spring in response to increasing flows in the Murray River.

Most of the potential watering actions planned in 2021-22 were fully achieved. Environmental flow objectives at Nyah Floodplain, Vinifera Floodplain, Bidgee Lagoons and Fishers Lagoon were met by natural inflows from the Murray River. Run-off from local rainfall helped meet environmental watering objectives for Murray hardyhead at Lake Koorlong and Lake Hawthorn, which reduced the total volume of water for the environment that was pumped to those sites. Water for the environment was delivered as planned to Robertson's Creek, Brickworks Billabong, Burra Creek South and Burra Creek South Proper. Since 2018-19, Lake Carpul and Lake Powell have remained dry to support dry-phase ecosystem processes.

The only planned environmental watering action for the lower Murray wetlands that was not achieved in 2021-22 was an autumn fill at Burra Creek North. Watering at the site currently relies on temporary pumping, but the proposed pumping site was inaccessible in autumn due to private works. New water delivery infrastructure is due to be built at Burra Creek North during 2022-23 as part of the Victorian Murray Floodplain Restoration Project (VMFRP), and the site will be prioritised for watering in 2023-24.

Scope of environmental watering

Table 5.2.14 describes the potential environmental watering actions in 2022-23, their expected watering effects (that is, the intended physical or biological effects of the watering action) and the longer-term environmental objectives they support. Each environmental objective relies on one or more potential environmental watering actions and their associated physical or biological effects.

Table 5.2.14 Potential environmental watering actions, expected watering effects and associated environmental objectives for the lower Murray wetlands

Potential environmental watering action	Expected watering effects	Environmental objectives
Brickworks Billabong (top up in spring, top-ups as required over summer/autumn)	• Maintain water levels (the target water level is between 30.8 m AHD and 31.6 m AHD) to inundate benthic herblands, including ruppia beds, to provide nursery habitat for Murray hardyhead and provide high levels of aquatic productivity • Maintain water quality suitable for Murray hardyhead • Provide shallow-water habitat and exposed mudflats to support foraging and resting of waterbirds, including migratory waterbirds	
Catfish Billabong (top up winter/spring)	• Fill to 33.5 m AHD to inundate fringing woodland vegetation to improve condition and recruitment • Allow water level to draw down over summer and autumn to: - promote the growth of a range of aquatic macrophytes that favour different water depth and inundation patterns - provide suitable foraging conditions for wading shorebirds • Maintain water levels above 30.8 m AHD to maintain permanent habitat for large-bodied and small-bodied native fish	
Heywood's Lake (fill in autumn)	• Fill to 56.8 m AHD to inundate fringing black box to stimulate growth and flowering to improve condition and recruitment • Provide a range of temporary open-water and shallow-water habitats to trigger the growth of various aquatic macrophytes and provide feeding and breeding opportunities for a variety of waterbirds	
Koorlong Lake (fill in spring, top-ups as required)	• Increase and maintain the water level (the target water level is between 36.7 m AHD and 38.0 m AHD) to support the growth of saline aquatic vegetation, including ruppia, to provide nursery habitat for Murray hardyhead and provide high levels of aquatic productivity • Maintain water levels within a 30 cm range to provide feeding resources for shorebirds and to maintain the Murray hardyhead population	

Potential environmental watering action	Expected watering effects	Environmental objectives
Lake Carpul (fill in spring)	• Provide a range of open-water, shallow-water and emergent-vegetation habitats for water-dependent birds to support breeding and feeding opportunities • Inundate and wet outer fringing river red gum, black box, lignum and vegetation communities (the target water level is 52.23 m AHD) to improve their condition • Mobilise carbon and nutrients within the wetland to support wetland processes	
Lake Hawthorn (fill in spring, top-ups as required)	• Achieve a target water level between 33 m AHD and 33.3 m AHD to: - increase and maintain a water level to encourage the germination and growth of ruppia to provide nursery habitat for Murray hardyhead and visitation by shorebirds - maintain the water level within a 30 cm range to provide feeding resources for shorebirds and to maintain the Murray hardyhead population	
Lake Powell (fill in spring)	• Provide a range of open-water, shallow-water and emergent-vegetation habitats for water-dependent birds to support breeding and feeding opportunities • Inundate and wet fringing river red gum, black box, lignum and vegetation communities (the target water level is 51.05 m AHD) to improve their condition • Mobilise carbon and nutrients within the wetland to support wetland processes	
Little Heywood's Lake (fill in autumn)	• Fill to 56.8 m AHD to inundate the fringing black box community to stimulate its growth and flowering to improve condition and recruitment • Provide a range of temporary open-water, shallow-water and emergent-vegetation habitats to provide feeding and breeding opportunities for a variety of waterbirds	
Nyah Floodplain (fill in autumn)	• Inundate the base and littoral zone of Parnee Malloo Creek (the target water level is 63.2 m AHD) to support plant communities • Improve the condition of vegetation communities to provide a range of habitats and feeding and breeding resources for birds and frogs • Inundate the floodplain adjacent to Parnee Malloo Creek to promote the growth of herb and shrub layers • Inundate river red gum to improve their condition • Mobilise carbon and nutrients to promote chemical and biological processes	
Robertson Creek (top up in spring)	• Wet fringing river red gum, black box, lignum and vegetation communities (the target water level is 30.4 m AHD) to improve their condition • Provide lateral spread of freshwater to refresh local groundwater to support the condition of trees not directly inundated • Provide a range of open-water, shallow-water and inundated lignum habitats to provide waterbird feeding opportunities and help protect the highly culturally significant site in the adjacent landscape	
Robertson Wetland (partial fill in spring)	• Wet fringing river red gum, black box, lignum and vegetation communities (the target water level is 28.4-28.8 m AHD) to improve their condition • Inundate cane grass beds to improve their condition and resilience • Provide a range of open-water, shallow-water and inundated lignum habitat to provide waterbird feeding opportunities	

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Scenario planning

Table 5.2.15 outlines potential environmental watering and expected water use under a range of planning scenarios.

Brickworks Billabong, Catfish Billabong, Koorlong Lake and Lake Hawthorn are priorities for watering in 2022-23 under all climate scenarios. Brickworks Billabong, Koorlong Lake and Lake Hawthorn support endangered populations of Murray hardyhead and require top-ups each year to ensure salinity levels are maintained within an acceptable range to support submerged vegetation that provides habitat for this species. Catfish Billabong is a new site that supports populations of native fish and wading shorebirds. A new regulator is being built at Catfish Billabong, and watering is prioritised at this site under all scenarios to test the capacity of the new infrastructure to achieve the recommended watering regime.

Nyah Floodplain, Robertson Creek and Robertson Wetland are priority watering sites under dry, average and wet climate scenarios. Nyah Floodplain dried between 2018-19 and 2020-21 and was inundated by unregulated flows in the Murray River during 2021-22. Vegetation at Nyah Floodplain will benefit from a second inundation in two years, which will improve the condition of the site ahead of proposed construction works as part of the VMFRP that will prevent deliveries of water for the environment in 2023-24. Deliveries of water for the environment at Robertson Creek in 2020-21 and 2021-22 have improved the condition of fringing vegetation, including black box and red gum and the waterbird population. Watering the site in 2022-23 aims to consolidate these environmental outcomes and build resilience for future dry conditions. Robertson Wetland was partially inundated by unregulated flows in the Murray River during 2021-22, but most of the wetland has not been inundated since the 2016 floods. Watering at Robertson Wetland in 2022-23 will aim to improve the condition of fringing river red gum that require inundation between four and six years out of ten for optimal condition. Nyah Floodplain and Robertson Wetland may be watered naturally under a wet scenario if the Murray River floods.

Given natural inundation and deliveries of water for the environment achieved watering requirements for most sites on the lower floodplain in 2021-22, the plan under average and wet scenarios is to water sites higher on the floodplain that have exceeded their recommended drying phase. Targeted sites include Lake Carpul and Lake Powell (dry since 2017) and Heywood's Lake and Little Heywood's Lake (dry since 2015). It will be important to deliver water to these sites in 2022-23 where possible because VMFRP construction works will likely prevent them from being actively watered in 2023-24.

Bidgee Lagoons, Fishers Lagoon, Bullock Swamp, Burra Creek South, Burra Creek South Proper and Vinifera Floodplain will be allowed to draw down during 2022-23 (unless they are naturally flooded) to support dry-phase ecosystem processes in accordance with recommendations in their management plans. At Burra Creek South and Burra Creek South Proper, this dry-phase period aligns with planned construction works through VMFRP, which will be completed in 2024-25.

Table 5.2.15 Potential environmental watering for the lower Murray wetlands under a range of planning scenarios

Planning scenario	Drought	Dry	Average	Wet
Expected river conditions	• Natural flow in the Murray River is too low to connect to wetlands • Wetlands rely on the delivery of water for the environment; very low rainfall year-round and extremely hot and dry conditions in summer/autumn cause substantial wetland drying	• Short periods of high flow in the Murray River are possible, but overbank flow to wetlands is unlikely; low rainfall and very warm summer/autumn	• Sustained periods of high flow in the Murray River in late winter and early spring may wet some low-lying wetlands, but most wetlands will rely on water for the environment • Local rainfall may be high and provide run-off to some wetlands	• Lengthy periods of high flow and floods with major spills from storages, resulting in widespread wetting of the floodplain and most wetlands • Some reliance on water for the environment to achieve target water levels • Local rainfall may be high and will provide run-off to most wetlands

Planning scenario	Drought	Dry	Average	Wet
Potential environmental watering – tier 1 (high priorities)[1]	• Brickworks Billabong • Catfish Billabong • Koorlong Lake • Lake Hawthorn	• Brickworks Billabong • Catfish Billabong • Koorlong Lake • Lake Hawthorn • Nyah Floodplain • Robertson Creek • Robertson Wetland	• Brickworks Billabong • Catfish Billabong • Heywood's Lake • Koorlong Lake • Lake Carpul • Lake Hawthorn • Lake Powell • Little Heywood's Lake • Nyah Floodplain • Robertson Creek • Robertson Wetland	• Brickworks Billabong • Catfish Billabong • Heywood's Lake • Koorlong Lake • Lake Carpul • Lake Hawthorn • Lake Powell • Little Heywood's Lake • Nyah Floodplain • Robertson Creek • Robertson Wetland
Possible volume of water for the environment required to achieve objectives[1]	• 2,800 ML (tier 1)	• 6,000 ML (tier 1)	• 13,300 ML (tier 1)	• 10,800 ML (tier 1)
Priority carryover requirements for 2023-24	• N/A			

1 Tier 1 potential environmental watering at the lower Murray wetlands is not classified as tier 1a or 1b because the water available for use is shared across various systems, and it is not possible to reliably determine the supply specifically available for the lower Murray wetlands.

5.2.7 Lindsay, Mulcra and Wallpolla islands

System overview

Lindsay, Mulcra and Wallpolla islands cover over 26,100 ha of Victorian floodplain in the Murray-Sunset National Park (see Figure 5.2.6). They form part of the Chowilla Floodplain and Lindsay-Wallpolla islands icon site that straddles the Victoria–South Australia-New South Wales border in the mid-Murray River system.

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

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

Flows in the mid-Murray River system are regulated through a series of weir pools. The weir pools are colloquially called locks, in reference to structures at the weirs that allow vessels to navigate from one weir pool to the next. The weir pools are primarily managed as small water storages to ensure adequate water levels for off-stream diversion via pumps and regulated channels.

Water is diverted from weir pool 9 in the Murray River to Lake Victoria, where it is stored for later use to meet South Australian water demands. The diversion causes water to bypass Murray River weir pools 7 and 8, and at times it can significantly impact flow in those reaches.

In recent years, the water levels in weir pools 7 and 8 have been managed to achieve ecological benefits in the Murray River channel. For example, weir pool levels have been raised during winter and spring and then lowered during summer and autumn to mimic seasonal river flows. The raising and lowering provide greater environmental benefits than a stable weir pool, because it wets and dries off-channel habitats and creates more variable flow patterns in the Murray River and connected floodplain streams. Changes in water levels during appropriate seasons help establish fringing vegetation in shallow margins of the river channel and promote the cycling of nutrients and carbon as conditions fluctuate between wet and dry.

Static weir pool levels and reduced flow in the Murray River have a big effect on flow in the Lindsay River and Potterwalkagee Creek. When natural flow increases and/or when water levels in weir pools 7 and 8 are raised above the full supply level, the upper Lindsay River starts flowing (Lock 7) and flow to Potterwalkagee Creek increases (Lock 8). When weir pools are lowered, flow to both the Lindsay River and Potterwalkagee Creek ceases. Mullaroo Creek on Lindsay Island is less affected by weir pool levels, and flow is controlled independently through the Mullaroo Creek regulator, which connects the creek and the Murray River. Moderate lowering of the lock 7 weir pool level has little effect on Mullaroo Creek but lowering more than 0.5 m below full supply level makes it difficult to deliver the recommended minimum flow of 600 ML per day that is required to maintain fast-flowing habitat for native fish, especially Murray cod.

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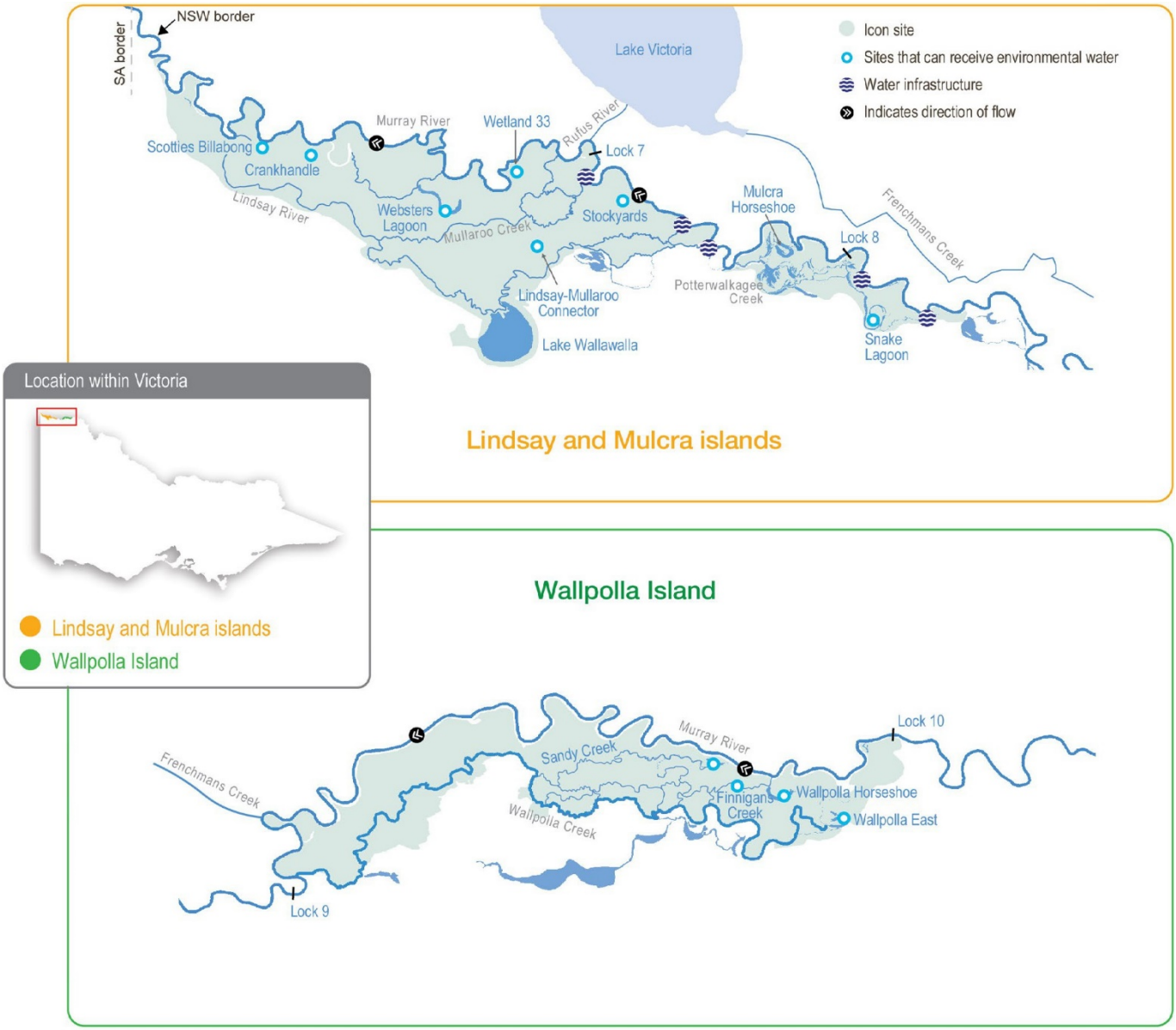
Fluctuation of weir pool levels is a major consideration for jurisdictions managing flow in the Murray River and the anabranch waterways of Lindsay, Mulcra and Wallpolla islands. Environmental objectives and associated water regimes for the Murray River sometimes conflict with those for the Lindsay,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

Figure 5.2.6 The Lindsay, Mulcra and Wallpolla islands



Environmental values

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

Mullaroo Creek supports one of the most significant populations of Murray cod in the mid-Murray River system. Mullaroo Creek provides fast-flowing habitat that Murray cod favour, which contrasts with the artificially slow-flowing and still habitats in the nearby Murray River weir pools. Fish in Mullaroo Creek breed and produce juveniles that contribute to populations in adjacent parts of the Murray system (such as in the Darling River in NSW and the lower Murray River in South Australia). Waterways and wetlands throughout the icon site support several other fish species, including freshwater catfish, golden perch, silver perch, Murray-Darling rainbowfish and unspecked hardyhead.

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

Environmental watering objectives in Lindsay, Mulcra and Wallpolla islands

Icon	Environmental objectives in Lindsay, Mulcra and Wallpolla islands[1]
	By 2030, increase the abundance of small-bodied native fish and the spread of age classes for long-lived native fish, compared to 2006 baseline levels
	Maintain (continuously) or improve (by 2030) populations of flow-dependent fauna
	By 2030, improve the function of water-dependent ecosystems by improving productivity linkages between river and floodplain habitats
	Maintain (continuously) or improve (by 2030) populations of flow-dependent threatened flora Maintain the extent and improve the condition of river red gum, black box and lignum compared to 2006 baseline levels by 2030 By 2030, improve the species richness and abundance of native wetland and floodplain aquatic vegetation functional groups
	Maintain communities and species diversity of colonial nesting waterbirds, waterfowl, waders and animals that feed on fish By 2030, increase populations of colonial nesting waterbirds at Lake Wallawalla and non-colonial waterbirds at Mulcra Horseshoe and Wallpolla Horseshoe

1 All objectives are derived from the Mallee CMA's 2021 *Lindsay Mulcra and Wallpolla Islands Environmental Watering Management Plan* and generally include targets for improving environmental values to be achieved by 2030. Objectives for maintaining the condition of environmental values are not time-bound and should be achieved each year continuously until 2030 and beyond.

Traditional Owner cultural values and uses

The First People of the Millewa-Mallee Aboriginal Corporation (representing Latji Latji and Ngintait Traditional Owners) has identified ways in which water for the environment can support cultural values and uses at the Lindsay-Mulcra-Wallpolla islands icon site. These are explained in Table 5.2.16.

Mallee CMA usually meets on Country with the First People of the Millewa-Mallee Aboriginal Corporation to discuss watering requirements for their Country. COVID-19 restricted opportunities to meet on Country during 2021-22, so Mallee CMA used small-group discussions in early 2022 as well as previous recommendations from Traditional Owners to inform proposed deliveries of water for the environment in 2022-23.

Ngintait Traditional Owners support proposed watering at Mulcra Island and Potterwalkagee Creek in 2022-23.

Table 5.2.16 Traditional Owner values and uses at the Lindsay-Mulcra-Wallpolla islands icon site

Waterway	Traditional Owner group	Values/uses/objectives/opportunities
Lindsay Island	Ngintait	• Black swans — a totemic species —nest in bull rush. Traditional Owners have observed a lack of bull rush around certain areas, so they would like to see it restored along the riverbanks, creating more nesting opportunities and a greater black swan population.
Lindsay Island	Ngintait	• Three-pronged grass is used for weaving. Traditional Owners are looking at places to plant seeds to grow this species, so Elders can sit with the community and teach weaving using the grass.
Lindsay-Mulcra-Wallpolla islands	Ngintait/Latji Latji	• Old man weed, which grows in mud as water recedes, is used for bush medicine. Both Traditional Owner groups from the Lindsay, Mulcra and Wallpolla region would like to see more of this. • Ngintait/Latji Latji want totemic species, including black swans, frogs, turtles, catfish, possums and ducks, protected, and their numbers increased.
Lindsay-Mulcra-Wallpolla islands	Latji Latji	• Latji Latji would like more opportunities to get back onto Country and further discussions about managing Country.

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Social, recreational and economic values and uses

In planning the potential watering actions in Table 5.2.18, Mallee CMA has also considered how environmental flows could support other values and uses, including:

- water-based recreation (such as canoeing, kayaking, fishing and yabbying)
- riverside recreation and amenity (such as bushwalking, camping, bird and wildlife watching, four-wheel driving and photography)
- community events and tourism (such as increased and longstanding repeat visitation, ecotourism and educational programs for school, TAFE and university students)
- socio-economic benefits (such as for commercial beekeepers who rest bees around the floodplain away from crops and pesticides ready for the next season, local businesses providing accommodation and hospitality to tourists, researchers and local water delivery contractors).

Recent conditions

Rainfall across Lindsay, Mulcra and Wallpolla islands during 2021-22 was close to the long-term average, and maximum temperatures were slightly above average.

In 2021-22, allocations against high-reliability water shares reached 52 percent in August and 100 percent in October. Low-reliability water shares began receiving allocations in December and reached their full allocations in February. This is the first time Murray seasonal determinations reached maximum availability since the introduction of the current entitlement products in 2007. Spills from Hume Dam resulted in the deduction of most spillable carryover from 2020-21. Section 5.2 has more information about the resource position of water for the environment in the Victorian Murray system during 2021-22.

Increased flow in the Murray River (driven by rainfall and storage spills in the upper Murray and Murrumbidgee catchments) from October to December 2021 filled some low-lying floodplain wetlands and increased flows through anabranch waterways on Lindsay, Mulcra and Wallpolla islands.

Deliveries of water for the environment for the Lindsay, Mulcra and Wallpolla islands were managed in line with an average climate scenario during 2021-22. All the watering actions planned for the year were fully achieved through a combination of natural and environmental flows.

On Lindsay Island, natural flows in spring filled Scotties Billabong, Stockyards and Wetland 33. Lake Wallawalla and Crankhandle did not fill naturally, and water for the environment was delivered to these sites via pumps. The Lindsay-Mullaroo Connector was partially filled by natural flows in spring and topped up via pumping in autumn. Flows through the Lindsay River and Mullaroo Creek increased through spring in response to increased flow in the Murray River.

Weir pool eight in the Murray River was raised during spring 2021 to increase flow in Potterwalkagee Creek and spread water onto the Mulcra Island floodplain for the first time since 2017. Increased flow in the Murray River during spring 2021 increase the weir pool height and pushed water further onto the Mulcra floodplain. Annual condition monitoring indicates that the floodplain inundation in 2021 arrested the decline in the health of river red gum, black box and lignum communities and water-dependent understorey vegetation that has been observed in recent dry years. Ecologists recommend inundating Mulcra Island floodplain again in spring 2022, if possible, to consolidate the environmental benefits of the 2021 watering event.

Increased flow in the Murray River provided unimpeded flow through Wallpolla Horseshoe, Finnigans Creek and Wallpolla Creek on Wallpolla Island during spring, which allowed the dispersal of native fish that were stocked in Wallpolla Horseshoe in 2019.

Scope of environmental watering

Table 5.2.17 describes the potential environmental watering actions in 2022-23, their expected watering effects (that is, the intended physical or biological effects of the watering action) and the longer-term environmental objective(s) they support. Each environmental objective relies on one or more potential environmental watering actions and their associated physical or biological effects.

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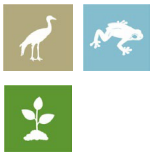
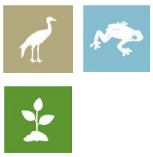
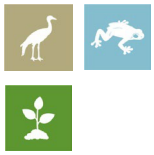
Table 5.2.17 Potential environmental watering actions, expected watering effects and associated environmental objectives for Lindsay, Mulcra and Wallpolla islands

Potential environmental watering action	Expected watering effects	Environmental objective(s)
Lindsay Island – Mullaroo Creek		
Year-round low flow (minimum of 600 ML/day)	• Maintain fast-flowing habitat for native fish (such as Murray cod, silver perch and golden perch) • Maintain habitat for aquatic vegetation and soil moisture to maintain the condition of streamside vegetation	
Spring high-low flow (1,200 ML/day for three months during September to November)	• Increase the extent and velocity of fast-flowing habitat to cue the movement and spawning and improve recruitment opportunities for native fish • Increase fish passage between Mullaroo Creek and the Murray River via the Mullaroo Creek regulator fishway	
Lindsay Island – Lindsay River		
Winter/spring/summer low flow via the northern regulator (45 ML/day for three months during August to December)	• Provide temporary flowing water to connect pools and support the dispersal and recruitment of small- and large-bodied native fish and the spawning of small-bodied native fish • Stimulate the release of carbon and nutrients from the sediment to increase the productivity of the floodplain food web • Maintain bank soil moisture to support the growth of streamside vegetation	
Winter/spring/summer low flow via the southern regulator (5 ML/day for three months during August to December)		
Lindsay Island wetlands		
Scotties Billabong (fill in spring)	• Provide shallow-water habitat to provide refuge (if conditions are dry in the next 2-3 years) and feeding habitat for frogs and waterbirds • Provide conditions for lake-bed herbaceous plants and semi-aquatic plants to grow in the littoral zone in the drying phase after watering • Maintain habitat for aquatic vegetation and provide soil moisture to maintain and improve the condition of river red gums and black box	
Mulcra Island – Potterwalkagee Creek		
Spring low flow via the Stony Crossing regulator (35-115 ML/day for three months during September to November)	• Provide temporary flowing water to connect pools and support the dispersal and recruitment of small- and large-bodied native fish, and the spawning of small-bodied native fish • Stimulate the release of carbon and nutrients from the sediment to increase the productivity of the floodplain food web • Maintain soil moisture to maintain the condition of streamside vegetation	
Spring low flow via the upper Potterwalkagee Creek regulator (15 ML/day for three months during September to November)		
Winter/spring overbank flow via the Stony Crossing regulator (470 ML/day for four months during August to November)	• Connect Potterwalkagee Creek to its floodplain to allow the exchange of nutrients and carbon between the floodplain and the Murray River system • Provide off-channel habitat for small-bodied fish to feed and breed	
Winter/spring overbank flow via the upper Potterwalkagee Creek regulator (420 ML/day for four months during August to November)		

Mulcra Island wetlands		
Mulcra Horseshoe (fill in spring)	• Provide shallow and open-water habitat to create foraging and breeding opportunities for waterbirds • Provide shallow-water habitat to provide refuge (if conditions are dry in the next 2-3 years) and feeding habitat for frogs • Stimulate the growth of emergent, aquatic and streamside vegetation • Provide moisture for lake-bed herbaceous plants to grow during the drying phase of the wetland	

Potential environmental watering action	Expected watering effects	Environmental objective(s)
Mulcra Island floodplain (floodplain inundation in spring)	• Provide shallow- and open-water habitat to create foraging and breeding opportunities for waterbirds • Increase soil moisture to maintain and improve the condition of streamside and floodplain vegetation, specifically river red gum, black box and lignum • Stimulate the release of carbon and nutrients from the sediment to increase the productivity of the floodplain food web • Provide a connection to the Murray River to allow the exchange of carbon and nutrients between the floodplain and the river	
Snake Lagoon extension (fill in spring)	• Provide shallow- and open-water habitat to create foraging and breeding opportunities for frogs and waterbirds • Increase soil moisture to maintain and improve the condition of streamside and floodplain vegetation, specifically river red gum, black box and lignum • Provide moisture for lake-bed herbaceous plants to grow during the drying phase of the wetland	
Wallpolla island		
Wallpolla Creek East (low flow in spring)	• Increase soil moisture to maintain and improve the condition of riparian vegetation, specifically black box • Provide a connection between Wallpolla Creek East and other tributaries of the Wallpolla Island floodplain to allow the exchange of carbon, nutrients and propagules through the system	
Wallpolla Horseshoe Lagoon (fill in spring)	• Wet/drown river red gum saplings in the inlet channel to Wallpolla Horseshoe to limit their coverage • Increase soil moisture to maintain and improve the condition of riparian vegetation, specifically river red gum • Provide shallow- and open-water habitat to create foraging and refuge opportunities for frogs and waterbirds • Stimulate the growth of emergent, aquatic and streamside vegetation	

Scenario planning

Table 5.2.18 outlines potential environmental watering and expected water use under a range of planning scenarios.

The two categories of environmental watering opportunities at Lindsay, Mulcra and Wallpolla islands in 2022-23 are:

- deliveries of water for the environment to anabranch waterways (Mullaroo Creek, Lindsay River and Potterwalkagee Creek) and floodplain wetlands in coordination with weir pool operation
- a program of environmental deliveries via temporary pumps to individual wetlands at Lindsay, Mulcra and Wallpolla islands.

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Anabranch and floodplain watering

Among the waterways and floodplain wetlands connected to the weir pools, two sites are proposed to receive water for the environment under all planning scenarios: Mullaroo Creek and Potterwalkagee Creek (via the Stony Crossing regulator). Permanent flowing water and a modest increase in flow in spring are essential for Mullaroo Creek in all scenarios, because there is strong evidence this watering regime promotes fish movement and breeding, particularly for Murray cod. Potterwalkagee Creek requires a low flow in most years to provide habitat for small-bodied native fish and larger flows for five in every 10 years to allow those fish to disperse between the creek and the Murray River, as well as to water higher terraces within the creek channel.

Under drought and dry scenarios, the operation of Murray River weir pools will only allow a low flow to be delivered to Potterwalkagee Creek. Floodplain inundation at Mulcra Island is a high priority under an average and wet scenario to consolidate benefits achieved from the watering in 2021. To achieve floodplain inundation in an average scenario, weir pool eight will be raised to increase flow in Potterwalkagee Creek (via the upper Potterwalkagee and Stony Crossing regulators), and flow will be temporarily held behind the lower Potterwalkagee Creek regulator to provide overbank flows and connection to the floodplain. Natural flooding under a wet climate scenario is likely to inundate large parts of the Mulcra Island floodplain.

Environmental flows are not proposed for Lindsay River under a drought climate scenario because weir pool seven will be operated at a level that is insufficient to provide flow to Lindsay River. Low flow is needed under dry to wet climate scenarios to connect pools and help disperse fish, plant propagules, carbon and nutrients between the Murray and Lindsay rivers. Under a dry or average scenario, the low flow will be delivered via regulators when weir pool 7 is raised. Flow through Lindsay River will likely be met naturally under a wet climate scenario.

Deliveries via temporary pumps

Five wetlands across Lindsay, Mulcra and Wallpolla islands are identified for deliveries using temporary pumps during 2022-23.

Watering the Snake Lagoon extension on Mulcra Island is a high priority under all scenarios because it has been dry since 2016, and a wet phase is required to replenish water-dependent vegetation and reduce the dominance of terrestrial plant species bordering the wetland. Mulcra Horseshoe still holds water from 2021-22, and it will likely provide refuge for aquatic fauna for two to three years without further top-ups if conditions turn dry. There is no plan to deliver extra water to Mulcra Horseshoe in 2022-23 under a drought scenario, but topping up the wetland is a high priority under all other scenarios to increase plant growth and provide foraging habitat for waterbirds that are likely to be abundant throughout the region. Water will need to be pumped into Mulcra Horseshoe in a dry scenario, but the wetland will likely fill as part of a managed floodplain watering event (via weir pool raising and increased flow in Potterwalkagee Creek) under an average scenario and through natural flooding under a wet scenario.

Scotties Billabong on Lindsay Island was partially filled in spring 2020 and naturally filled in spring 2021. Watering Scotties Billabong again in spring 2022 is a high priority under dry, average and wet climate scenarios because the impending construction activities associated with the VMFRP will limit watering opportunities during late 2023. Watering Scotties Billabong is a low priority under a drought scenario in 2022-23 because there are sufficient refuge sites elsewhere in the nearby landscape, and the minor inundation that occurred in 2021 improved the condition of the wetland vegetation enough to allow them to tolerate the next dry period.

At Wallpolla Island, watering is required at Wallpolla Horseshoe in all scenarios to maintain vegetation quality and stop the encroachment of terrestrial plants into the wetland: it will likely fill naturally under a wet scenario. Wallpolla Creek East is prioritised for water deliveries in a dry or average scenario to provide connectivity and the exchange of carbon, nutrients and propagules between creeks on Wallpolla Island. In a wet scenario, there may be enough natural connectivity through the system to achieve connection objectives, but some delivery of water for the environment may be necessary if the outcomes are only partially achieved. Watering Wallpolla Creek East is a low priority under a drought scenario in 2022-23 to conserve water and because there are sufficient refuge sites elsewhere in the nearby landscape.

Crankhandle, Finnigans Creek, Lake Wallawalla, Lindsay-Mullaroo Connector, Sandy Creek and Stockyards were filled during 2021-22 by natural flows or deliveries of water for the environment. Water will not be delivered to these sites during 2022-23 to allow them to continue to draw down and support dry phase outcomes (such as providing foraging habitat for wading waterbirds and allowing the growth of lake-bed herbland communities). Offsetting wetting and drying phases in different wetlands across Lindsay, Mulcra and Wallpolla islands in non-flood years provides a variety of habitat types and resources for waterbirds, terrestrial birds and other animals.

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Table 5.2.18 Potential environmental watering for Lindsay, Mulcra and Wallpolla islands under a range of planning scenarios

Planning scenario	Drought	Dry	Average	Wet
Expected river conditions	• Year-round low flow in the Murray River and no natural floodplain wetting • Weir pools will be maintained at full supply level in spring and drawn down below full supply level during summer, autumn and winter • Substantial wetland drying will occur	• Rare high-flow events in the Murray River and no natural floodplain wetting • Weir pools will be raised in spring and drawn down below full supply level in summer, autumn and winter • Substantial wetland drying will occur	• Short periods of high flow, most likely in spring/ summer, providing minor wetting of the floodplain • Weir pool levels will be maintained at full supply level or raised in winter/ spring and summer and drawn down in summer, autumn and winter	• Long periods of high flow, with major spills from storages resulting in widespread wetting of the floodplain and wetting of most wetlands • Weirs would be removed to allow the passage of natural flow
Lindsay Island				
Potential environmental watering – tier 1 (high priorities)[1]	• Year-round low flow (Mullaroo Creek) • Spring high-low flow (Mullaroo Creek)	• Year-round low flow (Mullaroo Creek) • Spring high-low flow (Mullaroo Creek) • Winter/spring/ summer low flow (Lindsay River via the north and south regulator) • Scotties Billabong (fill in spring)	• Year-round low flow (Mullaroo Creek) • Spring high-low flow (Mullaroo Creek) • Winter/spring/ summer low flow (Lindsay River via the north and south regulator) • Scotties Billabong (fill in spring)	• Year-round low flow (Mullaroo Creek) • Spring high-low flow (Mullaroo Creek) • Winter/spring/ summer low flow (Lindsay River via the north and south regulator) • Scotties Billabong (fill in spring)

Planning scenario	Drought	Dry	Average	Wet
Possible volume of water for the environment required to achieve objectives[2]	• 0-100 ML (tier 1)	• 200-400 ML (tier 1)	• 100-400 ML (tier 1)	• 0 ML (tier 1)
Mulcra Island				

Potential environmental watering – tier 1 (high priorities)[1]	• Snake Lagoon extension (fill in spring) • Spring low flow (Potterwalkagee Creek via Stony Crossing regulator)	• Snake Lagoon extension (fill in spring) • Spring low flow (Potterwalkagee Creek via Stony Crossing and upper Potterwalkagee Creek regulators) • Mulcra Horseshoe (fill in spring)	• Snake Lagoon extension (fill in spring) • Spring low flow (Potterwalkagee Creek via Stony Crossing and upper Potterwalkagee Creek regulators) • Overbank flow (Potterwalkagee Creek via Stony Crossing and upper Potterwalkagee Creek regulators) • Mulcra Horseshoe (fill in spring) • Mulcra floodplain inundation (floodplain inundation in spring)	• Snake Lagoon extension (fill in spring) • Spring low flow (Potterwalkagee Creek via Stony Crossing and upper Potterwalkagee Creek regulators) • Overbank flow (Potterwalkagee Creek via Stony Crossing and upper Potterwalkagee Creek) • Mulcra Horseshoe (fill in spring) • Mulcra floodplain inundation (floodplain inundation in spring)
Possible volume of water for the environment required to achieve objectives[3]	• 110 ML (tier 1)	• 1,110 ML (tier 1)	• 3,610 ML (tier 1)	• 110 ML (tier 1)
Wallpolla Island				
Potential environmental watering – tier 1 (high priorities)[1]	• Wallpolla Horseshoe (fill in spring)	• Wallpolla Horseshoe (fill in spring) • Wallpolla Creek East (fill in spring)	• Wallpolla Horseshoe (fill in spring) • Wallpolla Creek East (fill in spring)	• Wallpolla Horseshoe (fill in spring) • Wallpolla Creek East (fill in spring)
Possible volume of water for the environment required to achieve objectives	• 400 ML (tier 1)	• 1,900 ML (tier 1)	• 1,900 ML (tier 1)	• 0-1,500 ML (tier 1)

1 Tier 1 environmental watering at Lindsay, Mulcra and Wallpolla islands is not classified as tier 1a or tier 1b because the water available to use is shared across various systems, and it is not possible to reliably determine supply specifically available for the islands.
2 These estimates include the use of water for the environment for Mullaroo Creek, Lindsay River and the Lock 7 weir pool. Water for the environment used at these sites may be accounted for in Victoria or New South Wales.
3 The estimates include the use of water for the environment for Potterwalkagee Creek, Mulcra Island and the Lock 8 weir pool. Water for the environment used at these sites may be accounted for in Victoria or New South Wales.

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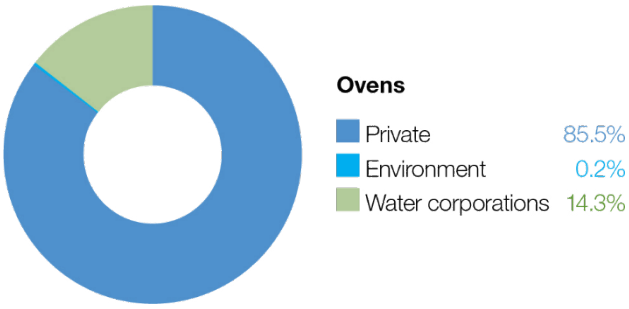
5.3 Ovens system

Waterway manager – North East Catchment Management Authority

Storage manager – Goulburn-Murray Water

Environmental water holder – Commonwealth Environmental Water Holder

Proportions of water entitlements in the Ovens basin held by private users, water corporations and environmental water holders on 30 June 2020



System overview

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

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

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

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

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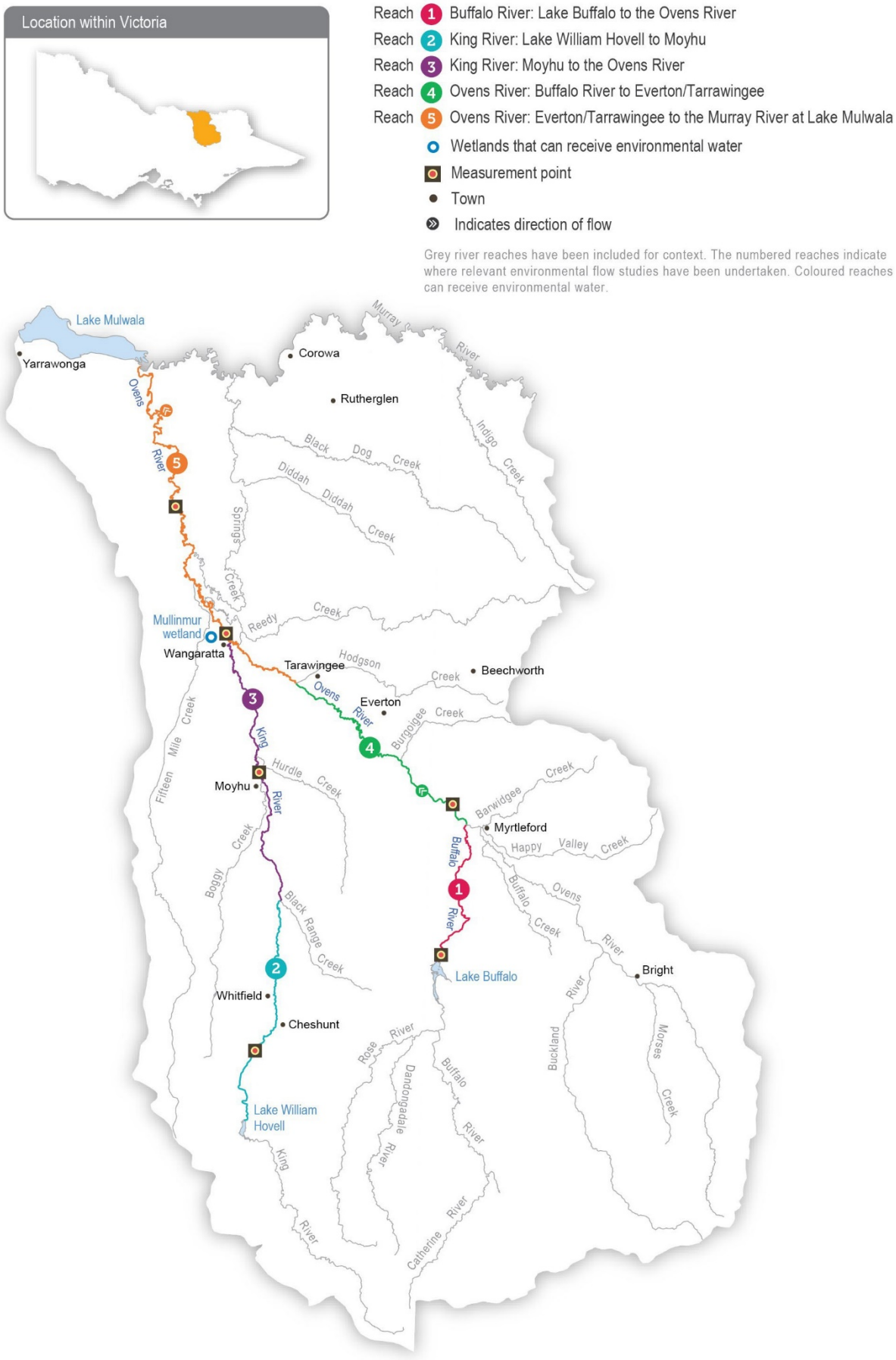
Figure 5.3.1 The Ovens system



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Environmental values

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

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

Water for the environment was delivered to Mullinmur Wetland at Wangaratta for the first time in 2019-20. This site has been the focus of several environmental improvement projects in recent years. Specific management actions include carp removal, a revegetation program and the re-introduction of native fish.

Environmental watering objectives in the Ovens system

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

Traditional Owner cultural values and uses

North East CMA consulted the Taungurung Land and Waters Council and the Yorta Yorta Nation Aboriginal Corporation in planning for potential 2022-23 environmental flows in the Ovens system.

The Taungurung Land and Waters Council water knowledge group Baan Ganalina (Guardians of Water) supports increasing Taungurung influence in water management, building internal capacity and advancing Taungurung water rights.

The Taungurung Country Plan's water chapter *Baan Dhumba-Dji-Ngan Mundak Gunga* (We must speak to protect water) lists several water objectives. These include increasing and strengthening Taungurung voices, increasing water literacy and capacity, and returning water to disconnected wetlands. The future delivery of water for the environment by the Taungurung Land and Waters Council on Taungurung Country would contribute to achieving some of these objectives.

The Taungurung Land and Waters Council has a 39 ML entitlement in Lake William Hovell and has transferred unused portions of its annual allocation to the VEWH each year (2019-22) to support environmental flows in the King River to help meet the council's watering objectives and Taungurung cultural responsibilities to heal and care for Country.

The Yorta Yorta Nation Aboriginal Corporation has developed the *Yorta Yorta Whole-Of-Country Plan 2021-2030*, which outlines aspirations and directions for Yorta Yorta Country. The plan identifies the lower Ovens River as a very high priority for management actions. The plan will support more culturally informed planning for water in the lower Ovens River in the future.

North East CMA has started conversations with the Bangerang Aboriginal Corporation, which has expressed aspirations for Mullinmur Wetland. Bangerang Aboriginal Corporation is exploring a cultural burning trial at the site as well as mapping scar trees and traditional stories in partnership with the Rural City of Wangaratta.

Increasing the involvement of Traditional Owners in the planning and management of environmental flows and ultimately providing opportunities to progress towards self-determination within the environmental watering program is a core commitment of the VEWH and its agency partners. This is reinforced by a range of legislative and policy commitments, including the *Water Act 1989*, the Victorian Aboriginal Affairs Framework, the 2016 *Water for Victoria* and in some cases, agreements under the *Traditional Owner Settlement Act 2010*.

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Where Traditional Owners are more deeply involved in the planning and/or delivery of environmental flows for a particular site, their contribution is acknowledged in Table 5.3.1 with an icon. The use of this icon is not intended to indicate that these activities are meeting all the needs of Traditional Owners but is incorporated in the spirit of valuing their contribution and indicating progress towards deeper involvement.

Watering planned and/or delivered in partnership with Traditional Owners to support cultural values and uses

The Taungurung Land and Waters Council may consider using their water entitlement in the King River system to support environmental objectives as part of their goal of healing and caring for Country. The Taungurung Land and Waters Council's allocation has been released from Lake William Hovell four times as an environmental flow in partnership with the North East CMA, Goulburn-Murray Water and the VEWH to provide additional water to the King River and assist in healing Country.

Social, recreational and economic values and uses

In planning the potential watering actions in Table 5.3.1, North East CMA considered how environmental flows could support values and uses, including:

- water-based recreation (such as boating and fishing)
- riverside recreation and amenity (such as camping, visitation for mental/physical health and wellbeing)
- community events and tourism (such as providing a setting for community gatherings, outdoor school learning, sporting events and citizen science projects)
- socio-economic benefits (such as businesses used by anglers and stock and domestic uses which rely on water quality supported by water for the environment deliveries when natural flows are at their lowest from November to March).

A private landholder's water allocation of 56 ML from the King River system was transferred to the VEWH as a donation. This release was combined with an entitlement to water for the environment and the Taungurung Land and Waters Council contribution to provide an increase in flow in February 2022.

Environmental flows are planned for Mullinmur Wetland over summer to support aquatic vegetation and support a native catfish nursery at the site. The water is expected to support other benefits for the local community at this site, which is managed by the Catholic Education Department supported by Wangaratta Landcare and Sustainability Incorporated. A new education hub provides a space for environmental education for students from Galen Catholic College, young people attending the Borinya Wangaratta Community Partnership and other members of the local community, including a team of Waterwatch citizen scientists. These volunteers have been involved in monitoring changes in conditions for plant and fish species after deliveries of water for the environment.

Recent conditions

The Ovens catchment experienced above-average rainfall and average temperatures throughout 2021-22 as a La Niña event continued to influence climate conditions across eastern Australia. Inflows to Lake William Hovell were passed through the storage during winter and spring and were 144 percent of the long-term average for 2021-22. Inflows to Lake Buffalo were also passed through the storage during winter and spring and were 179 percent of the annual average for 2021-22. Periods of high rainfall in both catchments during spring and summer caused storage spills and provided natural freshes to the Buffalo and King rivers. Both storages opened the season at 100 percent allocations against environmental water shares. The Ovens River and reaches of the King and Buffalo rivers directly below their storages retained much of their natural flow variability throughout the year, with the flow at Wangaratta peaking above 16,000 ML per day (which is above the minor flood level) on three occasions during winter and spring.

Deliveries of water for the environment for the Ovens system were managed in line with an average scenario in 2021-22, and all planned watering actions were met through natural flows or water for the environment. Mullinmur Wetland was naturally connected to the Ovens River on multiple occasions throughout winter and spring 2021, and a planned top-up using water for the environment was not required. Held water for the environment was combined with allocations transferred from the Taungurung Land and Water Council and water donated by a private landholder to boost the low flow in the King River during February. A planned autumn fresh in reach 1 of the Buffalo River could not be delivered due to maintenance work, but the impact was likely minimal due to the significant flow variability in the natural flow during the year.

Fish surveys conducted by the Arthur Rylah Institute over the past two years have recorded Macquarie perch, trout cod and southern pygmy perch in the middle reaches of the King River and movement of golden perch into Mullinmur Wetland when it is connected to the Ovens River. Native freshwater catfish that were introduced to Mullinmur Wetland in 2019 have not been detected in follow-up surveys: they have presumably moved into the Ovens River during periods of natural connection.

Scope of environmental watering

Table 5.3.1 describes the potential environmental watering actions in 2022-23, their expected watering effects (that is, the intended physical or biological effects of the watering action) and the longer-term environmental objectives they support. Each environmental objective relies on one or more potential environmental watering actions and their associated physical or biological effects.

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Table 5.3.1 Potential environmental watering actions, expected watering effects and associated environmental objectives for the Ovens system

Potential environmental watering action	Expected watering effects	Environmental objectives
Mullinmur Wetland (top up during November to February)	• Maintain the water level within the wetland to support the growth and recruitment of aquatic vegetation • Maintain habitat for native fish	
Autumn fresh (one fresh of greater than 430 ML/day for three days in reaches 1 and 4 and greater than 130-260 ML/day for three days in reach 5 during March to April)	• Provide flow cues to stimulate the movement of native fish • Increase connectivity between pools for fish movement • Mix pools to improve the water quality • Provide small variations in river levels and velocity, to flush sediment from hard substrates and maintain waterbug habitat • Scour biofilm from the river bed	
Summer/autumn low-flow variability (greater than 80 ML/day for one to two days during February to March in reaches 1, 2 and 3)	• Increase connectivity between pools for fish movement • Provide small variations in river levels to move sediment and maintain waterbug habitat • Maintain sufficient oxygen levels	

Scenario planning

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

The weather and inflows into storages have a large effect on how water for the environment is likely to be used in the Ovens system. Under dry and average conditions, the highest priority will be to use available water for the environment to introduce some variability to the summer/autumn low flow to limit the duration of extremely low-flow or cease-to-flow events that can stress native fish and waterbugs. Under average and wet conditions, the objective will be to provide a greater flow, support fish movement and breeding and increase the abundance and diversity of waterbugs. There is not enough water for the environment to deliver the recommended autumn fresh in full, so releases of water for the environment will need to be timed to coincide with operational water releases. All the recommended environmental flows for the Ovens River system are expected to be met naturally under a wet climate scenario.

The main priority for Mullinmur Wetland in 2022-23 will be to provide top-ups throughout the warmer months to offset seepage and evaporation, maintain wetland vegetation and maintain habitat for native fish. This will likely require some active deliveries of water for the environment under drought and dry climate scenarios, but it may be met by natural connections to the Ovens River under average and wet climate scenarios.

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

Planning scenario	Drought	Dry	Average	Wet
Expected river conditions	• Possible winter/ early-spring natural fresh • Very low flow through summer and autumn • No bulk water release	• Possible winter/ early-spring natural fresh • Very low flow through summer and autumn • Bulk water release is unlikely	• High winter/spring natural freshes • Moderate flow in summer and autumn with occasional natural freshes • Bulk water release is likely	• High natural freshes and low flow throughout most of the year • Bulk water release is likely • All flow objectives are achieved naturally
Expected availability of water for the environment	• 123 ML			

Planning scenario	Drought	Dry	Average	Wet
Potential environmental watering – tier 1 (high priorities)	**Tier 1a (can be achieved with predicted supply)**			
	• Summer/autumn low flow variability • Mullinmur Wetland top-up	• Summer/autumn low flow variability • Mullinmur Wetland top-up	• Autumn fresh • Summer/autumn low flow variability • Mullinmur Wetland top-up	• Autumn fresh • Summer/autumn low flow variability • Mullinmur Wetland top-up
Possible volume of water for the environment required to achieve objectives	• 123 ML	• 123 ML	• 123 ML	• 0 ML

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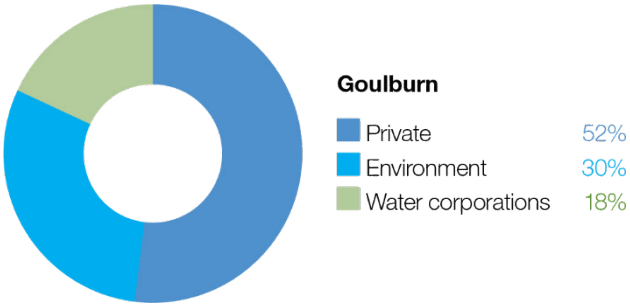
5.4 Goulburn system

Waterway manager – Goulburn Broken Catchment Management Authority

Storage manager – Goulburn-Murray Water

Environmental water holders – Victorian Environmental Water Holder (including the Living Murray Program) and Commonwealth Environmental Water Holder

Proportions of water entitlements in the Goulburn basin held by private users, water corporations and environmental water holders on 30 June 2020



The Goulburn system includes the Goulburn River and Goulburn wetlands.

5.4.1 Goulburn River

System overview

The Goulburn is Victoria's largest river basin, covering over 1.6 million ha or 7.1 percent of the state (Figure 5.4.1). The Goulburn River flows for 570 km from the Great Dividing Range upstream of Woods Point to the Murray River east of Echuca. It is an ancient, iconic river rich with environmental, cultural and recreational values.

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

The construction and operation of Lake Eildon and Goulburn Weir have significantly altered the natural flow regime of the Goulburn River. Water-harvesting during wet periods, and releases to meet irrigation and other consumptive demands during dry periods, means that flow below these structures is typically low in winter/spring and high in summer/autumn. This effectively reverses the natural seasonal flow pattern. Land use changes and the construction of small dams and drainage schemes have further modified the Goulburn River's flow regime. Levees and other structures prevent water from inundating the floodplain and filling many of the natural wetlands and billabongs. Several tributaries, including the Acheron, Yea and Broken rivers below Lake Eildon, add some flow variation on top of the Goulburn River's regulated flow regime. Large floods that cause the Goulburn River's storages to fill and spill are also important for the overall flow regime and its associated environmental values.

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

Environmental flow targets can sometimes be met by the coordinated delivery of operational water being transferred from Lake Eildon to the Murray River. These inter-valley transfers (IVTs) occur during the irrigation season between spring and autumn and may meet environmental flow objectives without the need to release water for the environment. In recent years, IVTs in the Goulburn River have significantly exceeded the environmental flow recommendations for summer and early autumn and have damaged bank vegetation and eroded the riverbanks. A new interim Goulburn to Murray trade rule and operating plan was introduced in 2021-22. It is intended to prevent further damage to the lower Goulburn River from prolonged high flow over summer and autumn.

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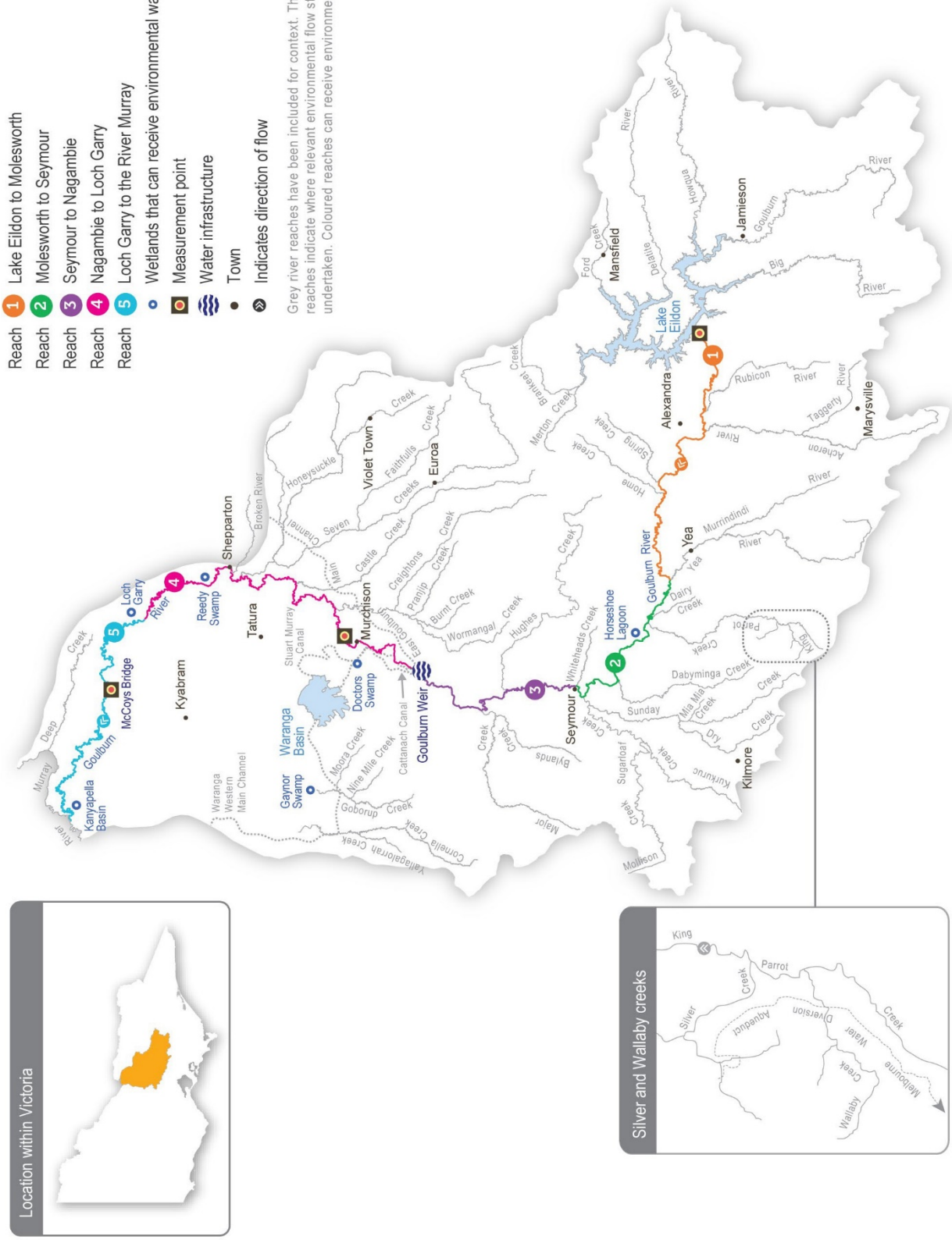
Figure 5.4.1 The Goulburn system



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Environmental values

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

The Goulburn River system is an important conservation area for threatened species. Several wetlands in the Goulburn catchment are formally recognised for their conservation significance. Tributaries of the mid-Goulburn River between Lake Eildon and Goulburn Weir host some of the last remaining Macquarie perch populations in the Murray-Darling Basin, while freshwater catfish occur in lagoons connected to reach 3 of the Goulburn River. Citizen science monitoring programs indicate the mid-Goulburn River supports a strong population of platypus, which are now classified as vulnerable under Victoria's *Fauna and Flora Guarantee Act 1988*. Monitoring in recent years shows that environmental flows in the lower Goulburn River trigger golden perch and silver perch to spawn. However, the extent to which these spawning events contribute to populations locally and in the wider southern basin is unknown. Self-sustaining populations of Murray cod have been confirmed, and trout cod are extending their range in the lower Goulburn River.

Environmental watering objectives in the Goulburn River

Icon	Environmental objectives in the Goulburn River
	Protect and increase populations of native fish
	Maintain the form of the riverbank and channel and a high diversity of river bed surfaces to support all stream life
	Increase populations of platypus
	Provide sufficient rates of carbon and nutrient production and processing to support native fish and waterbug communities
	Maintain populations of turtles
	Increase the abundance of aquatic and flood-tolerant plants in the river channel and on the lower banks to provide shelter and food for animals and stabilise the riverbank
	Maintain abundant and diverse waterbug communities to support riverine food webs
	Minimise the risk of hypoxic blackwater

Traditional Owner cultural values and uses

Goulburn Broken CMA consulted with the Taungurung Land and Waters Council and the Yorta Yorta Nation Aboriginal Corporation during seasonal water planning for the Goulburn River. The environmental and ecological objectives of the proposals were supported, and they align with the broad values of these Traditional Owner groups.

Increasing the involvement of Traditional Owners in the planning and management of environmental flows and ultimately providing opportunities to progress towards self-determination within the environmental watering program is a core commitment of the VEWH and its agency partners. This is reinforced by a range of legislative and policy commitments, including the *Water Act 1989*, the Victorian Aboriginal Affairs Framework, the 2016 *Water for Victoria* and in some cases, agreements under the *Traditional Owner Settlement Act 2010*.

Where Traditional Owners are more deeply involved in the planning and/or delivery of environmental flows for a particular site, their contribution is acknowledged in Table 5.4.1 with an icon. The use of this icon is not intended to indicate that these activities are meeting all the needs of Traditional Owners but is incorporated in the spirit of valuing their contribution and indicating progress towards deeper involvement.

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Watering planned and/or delivered in partnership with Traditional Owners to support cultural values and uses

The Taungurung Land and Waters Council indicated there is alignment between planned environmental flows in the mid-Goulburn River (Waring) and Taungurung objectives and responsibilities to heal and care for Country. Reach 1 baseflows, and the winter and spring freshes will help protect the landscape and health of the river. These flows will help support cultural values, protecting intangible cultural heritage, valued species, traditional food and medicine plants. The flows will also support ongoing efforts by Taungurung and partner organisations to care for the river and its floodplain, including investigations into rehabilitating degraded significant sites.

The Yorta Yorta Nation Aboriginal Corporation indicated there is alignment between planned watering actions in the lower Goulburn River (Kaiela) (reaches 4 and 5) and the cultural and ecological values of the Yorta Yorta People. A Yorta Yorta representative contributed to the 2020 Kaiela (Lower Goulburn River) Environmental Flows Study, which shaped planning for environmental flows in the lower Goulburn River during 2021-22 and beyond. Through this consultation, Yorta Yorta and Goulburn Broken CMA have identified that environmental flows are critical for culturally important plant and animal species. Flows encouraging spawning activity, recession flows to alleviate slumping of culturally important sites (such as middens and scar trees) and flows with a focus on reviving streamside vegetation are important to sustain food, fibre and medicine.

Social, recreational and economic values and uses

In planning the potential watering actions in Table 5.4.1, Goulburn Broken CMA considered how environmental flows could support values and uses such as:

- water-based recreation (such as boating, canoeing, fishing, gaming, hunting and kayaking)
- riverside recreation and amenity (for landholders and visitors)
- community events and tourism (such as paddling and boating businesses)
- socio-economic benefits (such as improving water quality for stock and domestic uses, irrigation diverters and water supply for settlements on the Goulburn River).

If the timing or management of planned environmental flows may be modified to align with a community benefit, this is acknowledged in Table 5.4.1 with the following icon.

Watering planned to support angling activities

The Goulburn River provides numerous recreational and economic benefits. Environmental flows support native fish populations by providing fish passage and habitat and by encouraging fish migration and spawning, which in turn provides benefits for recreational anglers. Following community feedback, the timing of a targeted environmental flow in November/December is planned to reduce impacts on river access around peak fishing periods, benefitting anglers and local businesses.

Recent conditions

Rainfall in the Goulburn catchment and inflows to Goulburn storages during 2021-22 were close to the long-term average. Natural flows contributed to winter and spring freshes, including a bankfull event of 19,500 ML per day at Shepparton in September. Allocations to high-reliability water shares reached 100 percent by October 2021, meaning sufficient water was available throughout the year to meet high-priority environmental flow requirements in the Goulburn River and support demands in the Broken, Campaspe and Loddon systems via trade.

Deliveries of water for the environment for the Goulburn system were managed in line with an average climate scenario throughout 2021-22. Most planned watering actions were fully or partially met with natural or environmental flows. A late-spring fresh was not delivered to allow newly germinated lower bank vegetation to establish. Natural flows delivered a winter fresh and spring fresh in the lower Goulburn River. Water for the environment was used to slow the recession after these natural events, to help optimise environmental outcomes. Water for the environment was also used to supplement lower-than-normal operational flow in reach 1 between March and November, to maintain habitat for fish and waterbugs and to deliver a spring and autumn fresh in the lower Goulburn River. The autumn fresh aimed to support bank vegetation and was timed to attract juvenile fish that recruited in the Murray River in the previous year. Ecologists used satellite tracking technology to monitor the movement of tagged golden perch and silver perch from the Murray River in response to freshes in the Goulburn River and other Murray tributaries. The results of that monitoring will inform future deliveries of water for the environment.

A new interim trade rule and operating plan for IVTs was introduced in 2021-22, which specifies the maximum monthly volumes of water that can be delivered from the Goulburn system to the Murray system. Wet conditions across the southern connected basin created low demand for IVTs from the Goulburn system, which meant the new trade rules were not tested. The low demand for IVTs also meant flow in spring and summer in the lower Goulburn River was within environmental flow recommendations for the first time since 2015-16. Ecological monitoring conducted during 2021-22 detected an improvement in vegetation condition on the banks of the lower Goulburn River compared to previous years and highlighted the importance of maintaining flows within environmental flow recommendations. Water for the environment will be used to build on bank vegetation recovery and support native fish migration in 2022-23.

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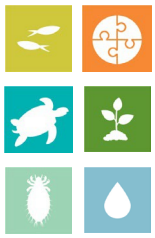
Scope of environmental watering

Table 5.4.1 describes the potential environmental watering actions in 2022-23, their expected watering effects (that is, the intended physical or biological effects of the watering action) and the longer-term environmental objectives they support. Each environmental objective relies on one or more potential environmental watering actions and their associated physical or biological effects.

Table 5.4.1 Potential environmental watering actions, expected watering effects and associated environmental objectives for the Goulburn River

Potential environmental watering action	Expected watering effects	Environmental objectives
Goulburn River reach 1		
Year-round low flow (400-2,000 ML/day in reach 1) 	• Maintain habitat for small-bodied native fish • Maintain adequate foraging habitat for platypus and reduce the risk of predation • Provide habitat and food for turtles • Wet and maintain riffles to provide habitat for biofilms and waterbugs • Additional benefits to reach 1 of the Goulburn River when flows delivered are above 800 ML/day: - scour fine sediment from the gravel bed and riffle substrate - maintain existing beds of in-channel vegetation - provide connection to off-stream wetland habitats, which increase food resources (waterbugs) available for fish and native animals	
Winter/spring fresh (one fresh of more than 5,000 ML/day for two days during July to September in reach 1) 	• Encourage female platypus to select a nesting burrow higher up the bank to reduce the risk of higher flow later in the year flooding the burrow when juveniles are present • Scour fine sediment from the gravel bed and riffle substrate • Maintain existing beds of in-channel vegetation	
Winter/spring off-stream habitat flow trial (one fresh of up to 6,000 ML/day for three days during May to June 2023 in reach 1) 	• Maintain off-stream habitat for small-bodied native fish and platypus • Scour fine sediment from the gravel bed and riffle substrate • Maintain existing beds of in-channel vegetation • Connect lower Goulburn River wetlands and anabranches to the river channel	
Goulburn River reach 4 and 5		
Year-round low flow (600-800 ML/day in reach 4 and 600-1,000 ML/day in reach 5)	• Provide slow, shallow habitat required for the recruitment of larvae/juvenile fish and habitat for adult small-bodied fish • Provide deep-water habitat for large-bodied fish • Submerge snags and littoral vegetation to provide habitat for fish and waterbugs and a substrate for biofilms to grow • Provide habitat and food for turtles • Maintain habitat for aquatic vegetation and water the root zone of low-bank vegetation • Vary flow within a specified range to encourage plankton production for food, disrupt biofilms and maintain water quality • Low, variable flow to enable vegetation to establish to protect against notching and bank erosion	

Potential environmental watering action	Expected watering effects	Environmental objectives
Winter/autumn fresh (one fresh of more than 7,300 ML/day for two days in reaches 4 and 5 during July to August 2022 and May to June 2023)	• Provide organic matter and carbon (e.g. leaf litter) to the channel • Provide connectivity to off-channel habitats and through the river for fish dispersal and greater food resources • Scour bed sediments to maintain pools and change in-channel complexity to improve habitat • Provide cues for platypus to nest higher up the bank • Provide sediment and plant propagules from tributary inflows after large rain events to encourage the establishment of new plants • Inundate and reduce terrestrial vegetation on low banks and trigger the recruitment of native, flood-tolerant streamside vegetation • Improve waterbug habitat and food availability by scouring fine sediments	
Pass a portion of the natural tributary flow in the mid-Goulburn to reaches 4 and 5 when flow in reach 3 is above 4,000 ML/day (1,000-5,000 ML/day in reaches 4 and 5 during May and October)	• Provide organic matter and carbon (e.g. leaf litter) to the channel • Transport and deposit seed, sediment and plant propagules on the riverbank	
Early-spring fresh (one fresh of up to 10,500 ML/day with more than seven days above 7,300 ML/day during September and October in reaches 4 and 5)	• Provide organic matter and carbon (e.g. leaf litter) to the channel • Provide connectivity to off-channel habitats and through the river for fish dispersal and greater food resources • Scour bed sediments to maintain pools and change in-channel complexity for improved habitat • Increase soil moisture in banks to improve the condition of existing native vegetation • Provide sediment and plant propagules from tributary inflows after large rain events to encourage the establishment of new plants • Inundate and reduce terrestrial vegetation on low banks and trigger the recruitment of native flood-tolerant streamside vegetation • Improve waterbug habitat and food availability by scouring fine sediments and biofilms from hard substrates	
Late-spring fresh (one fresh of more than 6,000 ML/day for two days during November and December in reaches 4 and 5) 	• Stimulate spawning of golden and silver perch • Scour bed sediments to maintain pools and change in-channel complexity for improved habitat • Improve waterbug habitat and food availability by scouring fine sediments and biofilms from hard substrates	

Potential environmental watering action	Expected watering effects	Environmental objectives
Autumn fresh (one fresh of more than 5,700 ML/day for two to five days during March and May in reaches 4 and 5)	• Cue fish to move into and through the system to increase their abundance and dispersal • Scour bed sediments to maintain pools, and change in-channel complexity for improved habitat • Increase soil moisture in banks for existing vegetation maintenance • Scour old biofilm from hard substrates to allow new biofilm growth to improve food and habitat for macroinvertebrates	
Slow recession of unregulated flow or releases from Goulburn Weir (3,000 ML/day and below in summer/autumn and from 6,000 ML/day in winter/spring in reaches 4 and 5)	• Minimise the risk of bank erosion associated with a rapid reduction in the water level • Transport and deposit seed, plant propagules and sediment on the riverbank • Minimise the risk of hypoxic blackwater after natural events	

Scenario planning

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

The recently updated environmental flows study for the Goulburn River recommends a range of watering actions that are needed most years to achieve the target environmental outcomes. High water availability in the Goulburn system at the end of 2021-22 and a strong resource outlook for 2022-23 mean all recommended watering actions can potentially be met, even under a return to dry conditions. Therefore, the proposed actions are the same for all planning scenarios in 2022-23.

Providing year-round low flow in all reaches of the Goulburn River is the highest priority under all climate scenarios. Year-round low flow in the mid-Goulburn river (reach 1) maintains habitat for fish, platypus, turtles and waterbugs, and it also ensures in-stream vegetation remains inundated and persists through the non-irrigation season when operational flow ceases. Year-round low flow in the lower Goulburn River (reaches 4 and 5) provides habitat for fish and macroinvertebrates and helps lower bank vegetation to recover following multiple years of high operational flows during warmer months. Water for the environment in the lower Goulburn River continues to focus on vegetation recovery, to improve the condition of the lower banks that showed signs of recovery in 2021-22 following lower-than-normal demand for IVTs. Goulburn-Murray Water generally diverts a proportion of the natural high flow from Goulburn Weir into the Waranga Basin. These operational transfers can cause the flow rate in the lower Goulburn River to drop rapidly after a natural high-flow event. Water for the environment may be used as required to slow the recession of natural spills at Goulburn Weir, reduce the risk of bank slumping, improve water quality and provide a more natural flow pattern for native fish.

Delivering a winter/autumn fresh in reaches 4 and 5 is a high priority under all climate scenarios to scour bed sediments, support channel-forming processes and improve habitat. In reach 1, a winter/spring fresh is a high priority under all scenarios to cue platypus to nest higher up the bank.

A winter/spring off-stream habitat flow trial is proposed in 2022-23 to connect low-lying wetlands and anabranches to the main river channel. Operational flows delivered from Lake Eildon mean these habitats are often wet in the summer months when they should be drawing down, and they dry through the winter months when they should be filling. The flow trial will assess ecological responses to a more natural watering regime and inform how infrastructure could be used to implement better water regimes in the future. The flow trial is a partnership project between Goulburn Broken CMA and the Taungurung Land and Waters Council, and it aims to boost environmental and Traditional Owner outcomes.

Timing deliveries of water for the environment alongside natural-flow events will again be a focus for 2022-23. Passing tributary flows from the mid-Goulburn River to the lower Goulburn River to provide variability through winter and spring is a high priority under all scenarios. Tributary flows following high-rainfall events carry more plant seed, nutrients and sediments that are beneficial to the lower Goulburn River than water released from Lake Eildon.

An early-spring fresh to prime the system and stimulate plant germination is a high priority under all climate scenarios. A late-spring fresh to trigger perch spawning is a tier 2 priority under all scenarios. Golden and silver perch are long-lived species that do not need to spawn annually to maintain good populations, and events delivered in November 2020 and 2021 achieved good spawning outcomes in the lower Goulburn River. However, if bank vegetation on the lower banks has had sufficient time to establish and is in good condition, or high natural flows have delayed germination, a late-spring fresh could be delivered under below-average to wet scenarios in 2022. There may not be sufficient water to deliver a late-spring fresh under drought and dry scenarios. If summer low-flow targets are met (that is, if IVTs are not too high), an autumn fresh will be delivered between March and May 2023 to maintain the bank vegetation and allow new seeds to germinate and provide a cue for native fish to move into the lower Goulburn River from the Murray River.

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Carrying over water to meet minimum low-flow objectives from July 2023 to September 2024 is an important consideration under drought and dry climate scenarios but is less important under average and wet scenarios due to likely high early-season allocations.

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

Planning scenario	Drought	Dry	Below average	Average	Wet
Expected river conditions	• Very few or no large natural-flow events • Blackwater could be an issue if there is a large rain event in the warmer months	• One to two short-duration, large, natural flow events are likely to provide small winter/spring freshes • Blackwater could be an issue if there is a large rain event in the warmer months	• Large natural-flow events are expected to provide some low flow for a few months from winter/mid-spring and are likely to provide small winter/spring freshes • Blackwater could be an issue if there is a large rain event in the warmer months	• Large natural-flow events will provide low flow for most of the year and will likely provide winter/spring freshes • Blackwater could be an issue if there is a large rain event in the warmer months	• Large natural-flow events will provide low flow and multiple freshes and/or overbank flow events in winter/spring
Expected availability of water for the environment[1]	• 438 GL	• 567 GL	• 567 GL	• 567 GL	• 567 GL
Goulburn River (targeting reach 1)					
Potential environmental watering – tier 1 (high priorities)[2]	**Tier 1a (can be achieved with predicted supply)**				
	• Year-round low flow • Winter/spring fresh • Winter/spring off-stream habitat flow trial	• Year-round low flow • Winter/spring fresh • Winter/spring off-stream habitat flow trial	• Year-round low flow • Winter/spring fresh • Winter/spring off-stream habitat flow trial	• Year-round low flow • Winter/spring fresh • Winter/spring off-stream habitat flow trial	• Year-round low flow • Winter/spring fresh • Winter/spring off-stream habitat flow trial
Goulburn River (targeting reaches 4 and 5)					
Potential environmental watering – tier 1 (high priorities)[3]	**Tier 1a (can be achieved with predicted supply)**				
	• Year-round low flow • Winter/autumn fresh • Pass mid-Goulburn tributary flows • Early-spring fresh • Autumn fresh • Recession flow management	• Year-round low flow • Winter/autumn fresh • Pass mid-Goulburn tributary flows • Early-spring fresh • Autumn fresh • Recession flow management	• Year-round low flow • Winter/autumn fresh • Pass mid-Goulburn tributary flows • Early-spring fresh • Autumn fresh • Recession flow management	• Year-round low flow • Winter/autumn fresh • Pass mid-Goulburn tributary flows • Early-spring fresh • Autumn fresh • Recession flow management	• Year-round low flow • Winter/autumn fresh • Pass mid-Goulburn tributary flows • Early-spring fresh • Autumn fresh • Recession flow management
Potential environmental watering – tier 2 (additional priorities)[2]	• Late-spring fresh	• Late-spring fresh	• Late-spring fresh	• Late-spring fresh	• Late-spring fresh

Planning scenario	Drought	Dry	Below average	Average	Wet
Possible volume of water for the environment required to achieve objectives	• 390,000 (tier 1a) • 50,000 ML (tier 2)	• 515,000 (tier 1a) • 50,000 ML (tier 2)	• 505,000 (tier 1a) • 50,000 ML (tier 2)	• 515,000 ML (tier 1a) • 50,000 ML (tier 2)	• 420,000 ML (tier 1a) • 50,000 ML (tier 2)
Priority carryover requirements for 2023-24	• 23,000 ML		• 0 ML		

1 When trading opportunities are available, additional allocations of water for the environment from the Murray River can be transferred to meet Goulburn demand.
2 A winter/spring off-stream habitat flow trial fresh is not required in 2023 if delivered in May to June 2022.
3 Preceding low-flow periods and bank vegetation condition triggers must be met before delivery of late-spring and autumn freshes are considered.

5.4.2 Goulburn wetlands

System overview

Within the Goulburn Broken catchment, there are about 2,000 natural wetlands identified, but only six — Doctors Swamp, Gaynor Swamp, Horseshoe Lagoon, Kanyapella Basin, Loch Garry and Reedy Swamp — have received water for the environment through VEWH or CEWH entitlements. Several other small wetlands in the Goulburn catchment have been watered under a separate arrangement through the Murray-Darling Wetlands Working Group.

Doctors Swamp, Gaynor Swamp, Kanyapella Basin, Loch Garry and Reedy Swamp can receive water for the environment through irrigation supply infrastructure. The volume of water that can be delivered to each wetland depends on the physical capacity of the infrastructure and the seasonal allocation. Water for the environment can be delivered from the Goulburn River to Horseshoe Lagoon via a temporary pump.

Environmental values

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

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

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

Horseshoe Lagoon is a paleochannel of the Goulburn River that has tall marsh, floodway pond herbland and floodplain streamside woodland vegetation communities. The lagoon supports numerous waterbird species and is home to three species of turtle, including the Broad-shelled Turtle.

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

Loch Garry is a paleochannel of the Goulburn River that provides deep, open-water habitat. The channel is surrounded by shallow, vegetated wetland depressions, red gum forest and sand ridges. It is an important site for waterbird feeding and roosting, and it is a drought refuge for eastern great egrets, musk ducks, nankeen night herons and royal spoonbills.

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

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Environmental watering objectives in the Goulburn wetlands

Icon	Environmental objectives in the Goulburn wetlands
	Maintain turtle populations
	Increase the diversity and cover of native wetland plant species consistent with ecological vegetation class benchmarks Reduce the cover and diversity of exotic plants Maintain populations of rigid water-milfoil, slender water-milfoil and river swamp wallaby grass
	Provide breeding habitat for waterbirds Provide feeding and roosting habitat for waterbirds

Traditional Owner cultural values and uses

Goulburn Broken CMA sought input from the Taungurung Land and Waters Council and the Yorta Yorta Nation Aboriginal Corporation on planning for water for the environment for the Goulburn wetlands. Both groups indicated they support the watering priorities planned for the year ahead and will continue to work with the CMA to implement these actions while exploring further opportunities to support their cultural values.

Increasing the involvement of Traditional Owners in the planning and management of environmental flows and ultimately providing opportunities to progress towards self-determination within the environmental watering program is a core commitment of the VEWH and its agency partners. This is reinforced by a range of legislative and policy commitments, including the *Water Act 1989*, the Victorian Aboriginal Affairs Framework, the 2016 *Water for Victoria* and in some cases, agreements under the *Traditional Owner Settlement Act 2010*.

Where Traditional Owners are more deeply involved in the planning and/or delivery of environmental flows for a particular site, their contribution is acknowledged in Table 5.4.3 with an icon. The use of this icon is not intended to indicate that these activities are meeting all the needs of Traditional Owners but is incorporated in the spirit of valuing their contribution and indicating progress towards deeper involvement.

	Watering planned and/or delivered in partnership with Traditional Owners to support cultural values and uses

The Taungurung Land and Waters Council has been involved in planning at Gaynor Swamp and Horseshoe Lagoon. Healing Country and Healing Knowledge are key values outlined in the *Cultural and Natural Resource Management Strategy*, and they align closely with environmental flow outcomes achieved with the delivery of water for the environment.

The first delivery of water for the environment to Horseshoe Lagoon in winter 2019 was celebrated by Taungurung women: the lagoon is a significant site, and this was an excellent example of working together to protect cultural values and heal Country. The Taungurung Land and Waters Council also participated in the development of the environmental water management plan for the site in 2019. The Taungurung water knowledge group Baan Ganalina (Guardians of Water) has worked closely with Goulburn Broken CMA, the VEWH and other partners to bring water back to the lagoon to restore habitats and see birds and other animals return to the site. In 2021, Taungurung Land and Waters Council staff and Baan Ganalina members coordinated the delivery of environmental flows to the site by managing the pumping and delivery. Following the delivery, Parks Victoria and the Taungurung Land and Waters Council have begun reintroducing aquatic plant species that are either missing or in low numbers to boost the diversity and abundance of aquatic plants.

The Taungurung Land and Waters Council has identified that water for the environment assists in:

- supporting the health of cultural values at the site by protecting intangible cultural heritage and valued species, traditional food and medicine plants
- exploring opportunities to reintroduce culturally informed management tools and practices
- supporting and securing access for Taungurung contemporary cultural practices and uses, teaching places, reconnection to Country and camping sites
- actively fulfilling Caring for Country responsibilities by restoring a more natural watering regime to degraded significant sites and rehabilitating habitat for native species
- supporting contemporary living biocultural knowledge exchange and integration through involvement in natural resource management decisions
- increasing Taungurung water literacy and understanding of conservation and water management within their Country
- increasing Taungurung internal capacity and confidence in water management following self-determination principles via engagement and joint management arrangements with Goulburn Broken CMA and Parks Victoria.

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Taungurung has a special interest in the rehabilitation of floodplain wetlands associated with the Goulburn River (Waring), but which are now largely disconnected from the main river channel due to the impacts of river flow regulation. The Taungurung Land and Waters Council is currently monitoring biocultural values and habitat conditions at six of the disconnected wetlands as part of an ongoing Reading Country program. This process and its findings will inform future seasonal watering proposals and planning for water for the environment. Currently, Taungurung is working with partners to enhance habitat conditions for native species in the area, and healthy Country assessments will provide important information about cultural objectives and indicators.

The Yorta Yorta Nation Aboriginal Corporation has been involved in planning for environmental flows at Doctors Swamp, Kanyapella Basin, Loch Garry and Reedy Swamp, including by participating in the development of environmental water management plans for these sites.

Yorta Yorta identified key cultural values at Doctors Swamp. Water for the environment supports nardoo (a food source), native grasses, old man weed (which has medicinal uses) and weaving (using sedges and rushes). Watering also supports a wide range of bird and animal species that provide a variety of cultural values. Yorta Yorta are supportive of planned drying at Doctors Swamp in 2022-23.

Kanyapella Basin plays an important role in the Yorta Yorta People's cultural and spiritual connections. It supports the health of cultural values in the landscape (such as Creation Story and traditional food and medicine plants). Before the delivery of environmental flows in winter 2020, Yorta Yorta People conducted a cultural burn at the site, helping to enable direct delivery of the water and help the growth of old man weed.

Environmental flows delivered to Loch Garry in April 2020 initiated a resurgence of culturally important food, fibre and medicinal plants. Giant rush thrived, providing nesting opportunities for important bird species. The site is rich in cultural values identified by the Yorta Yorta People, with stone scatters, marked trees and significant sand hills in the higher elevations. Yorta Yorta support planned drying at Loch Garry in 2022-23.

Social, recreational and economic values and uses

In planning the potential watering actions in Table 5.4.3, Goulburn Broken CMA considered how environmental flows could support values and uses, including:

- water-based recreation (such as canoeing)
- riverside recreation and amenity (such as birdwatching, camping, cycling, hiking, photography and walking)
- community events and tourism (such as community birdwatching events, the Nature Scripts Initiative and outdoor classroom learning).

Recent conditions

The Goulburn catchment experienced rainfall and temperature conditions close to the long-term averages throughout 2021-22, with particularly high rainfall in winter 2021 and summer 2022. Catchment storages also had above-average inflows, and allocations against high-reliability water shares across the Goulburn, Broken and Murray systems reached 100 percent by mid-October 2021.

Deliveries of water for the environment for the Goulburn wetlands were managed in line with an average climate scenario during 2021-22, and five out of the six planned watering actions were achieved through a combination of managed deliveriese and natural inflows.

Horseshoe Lagoon filled naturally in autumn 2021, and water for the environment was used to water deeper sections of the wetland in winter 2021. The watering triggered the growth of new vegetation, and numerous broad-shelled, common long neck and Murray River turtles were observed at the wetland.

Kanyapella Basin and Loch Garry were both filled with water for the environment in spring 2021. Monitoring detected positive responses by aquatic vegetation, native frogs and waterbirds. These wetlands have only been actively watered a few times, and the monitoring results will be used to help refine future environmental watering actions.

Doctors Swamp and Gaynor Swamp were both filled with water for the environment in autumn 2022. At the time of writing, monitoring results were not yet available, and delivery was still in progress at Gaynor Swamp. Delivery at Doctors Swamp had temporarily ceased due to capacity constraints within the Cattanach Canal, which needs to be near-full capacity for delivery to recommence.

The only planned watering action that was not delivered in 2021-22 was an autumn fill of Reedy Swamp. Reedy Swamp is a temporary freshwater wetland that benefits from periodic dry phases. It last filled in April 2020, and it was expected to dry out before the end of 2021. However, frequent rain events during 2021-22 have prevented complete drying, so a decision was made to defer the planned fill until spring 2023 to allow dry-phase plant species to grow and complete their life cycles.

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Scope of environmental watering

Table 5.4.3 describes the potential environmental watering actions in 2022-23, their expected watering effects (that is, the intended physical or biological effects of the watering action) and the longer-term environmental objective(s) they support. Each environmental objective relies on one or more potential environmental watering actions and their associated physical or biological effects.

Table 5.4.3 Potential environmental watering actions, expected watering effects and associated environmental objectives for the Goulburn wetlands

Potential environmental watering action	Expected watering effects	Environmental objectives
Gaynor Swamp (fill in spring 2022 and top up as required) 	• Provide nesting, breeding and feeding habitat for waterbirds, in particular for brolga • Inundate to less than 1 m depth to promote conditions for vegetation growth and flowering, particularly of southern cane grass and spiny lignum and planted river red gum saplings	
Horseshoe Lagoon (partial fill or top-up as required in winter 2022) 	• Inundate the deeper section and wetland margins to maintain wetland vegetation communities by supporting their growth and recruitment • Suppress the growth of weeds • Provide feeding and breeding habitat for turtle populations	
Kanyapella Basin (partial fill in autumn 2023) 	• Inundate deeper parts of the wetland to maintain soil moisture and promote vegetation communities to grow and flower • Support the growth of rigid water-milfoil and river swamp wallaby grass populations	

Scenario planning

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

A partial fill of Gaynor Swamp and Horseshoe Lagoon are high priorities across all climate scenarios in 2022-23. These watering actions are required to support an optimum watering regime and to support and build on ecological outcomes achieved in 2021-22. Gaynor Swamp was filled in autumn 2022 to support the growth of various wetland plants and improve nesting and feeding resources for potential waterbird breeding events later in the year. If breeding is triggered over winter, watering in spring 2022 to maintain water levels and vegetation materials will be of high importance. Horseshoe Lagoon naturally filled in autumn 2021, had a top-up in winter 2021 and dried in March 2022. A partial fill in winter 2022 will promote the growth of threatened plant species in the lower parts of the wetland that will have met their recommended dry period interval. It will also support dry-phase ecosystem processes in more elevated parts of the wetland complex.

A partial fill of Kanyapella Basin is a high priority in autumn 2023 under dry to wet climate scenarios to further establish aquatic vegetation (such as rigid water-milfoil and river swamp wallaby grass) that have benefitted from deliveries of water for the environment in 2020 and 2021. This site would not naturally receive water as often as some of the other Goulburn wetlands, so watering is not a priority under a drought scenario. Water for the environment will likely need to be actively delivered to Kanyapella Basin to achieve the planned watering action under dry and average climate scenarios, but it is likely to be filled to retard downstream floods under a wet scenario.

Doctors Swamp, Loch Garry and Reedy Swamp will not be deliberately watered in 2022-23 to allow them to draw down or remain dry to support dry-phase ecosystem processes. However, if natural inundation triggers a significant waterbird breeding event at either site, water for the environment may be delivered to help the chicks successfully fledge.

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

Planning scenario	Drought	Dry	Average	Wet
Expected river conditions	• Catchment run-off and natural flow into the wetlands are highly unlikely	• Catchment run-off and natural flow into the wetlands are unlikely	• Some catchment run-off and natural flow into some of the wetlands are likely, particularly in winter/spring	• Catchment run-off and natural flow into the wetlands are likely to fill or partially fill the wetlands, particularly in winter/spring
Potential environmental watering – tier 1 (high priorities)	• Gaynor Swamp • Horseshoe Lagoon	• Gaynor Swamp • Horseshoe Lagoon • Kanyapella Basin	• Gaynor Swamp • Horseshoe Lagoon • Kanyapella Basin	• Gaynor Swamp • Horseshoe Lagoon • Kanyapella Basin
Potential environmental watering – tier 2 (additional priorities)	• N/A			
Possible volume of water for the environment required to achieve objectives	• 1,120 ML (tier 1)	• 2,120 ML (tier 1)	• 2,120 ML (tier 1)	• 560 ML (tier 1)

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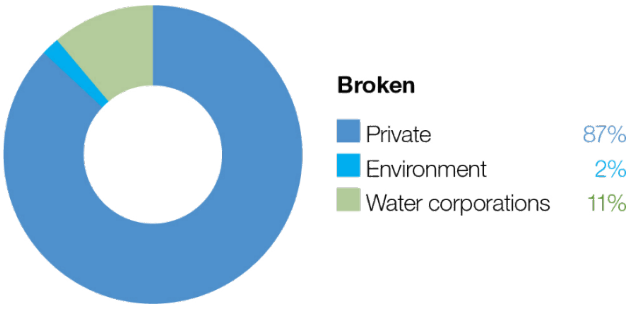
5.5 Broken system

Waterway manager – Goulburn Broken Catchment Management Authority

Storage manager – Goulburn-Murray Water

Environmental water holder – Victorian Environmental Water Holder

Proportions of water entitlements in the Broken basin held by private users, water corporations and environmental water holders on 30 June 2020



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

5.5.1 Broken River and upper Broken Creek

System overview

The Broken River is a tributary of the Goulburn River, rising in the Wellington-Tolmie highlands and flowing north-west to Benalla and then west for a total distance of 190 km before it joins the Goulburn River near Shepparton (Figure 5.5.1). Lake Nillahcootie is the main storage on the Broken River. It is about 36 km upstream of Benalla and harvests water from the river to support stock and domestic supply and irrigated agriculture. The main tributaries of the Broken River are Hollands Creek, Ryans Creek and Lima East Creek.

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

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

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

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

Delivery of water for the environment to the Broken River is primarily constrained by the small volume of water holdings in the Broken system. Environmental water holders can trade water into the Broken system from other trading zones subject to relevant limits and conditions to meet critical environmental needs.

The bulk entitlement for the Broken system held by Goulburn-Murray Water stipulates that minimum environmental flows — also known as passing flows — are to be maintained in the Broken River when there are natural flows into the system. The bulk entitlement also allows Goulburn-Murray Water and the VEWH to agree to reduce minimum passing flows and accumulate the unused volumes for later releases that will provide a greater environmental benefit. In recent years, passing flows have been reduced, accumulated and delivered to maintain low flow (on days when there are no passing flows due to no natural flow into the system) and freshes in the Broken River. Accumulated passing flows are the first volumes lost when the storage spills. Environmental flows in upper Broken Creek are restricted by the volume of available supply, channel capacity and the need to avoid flooding low-lying, adjacent land.

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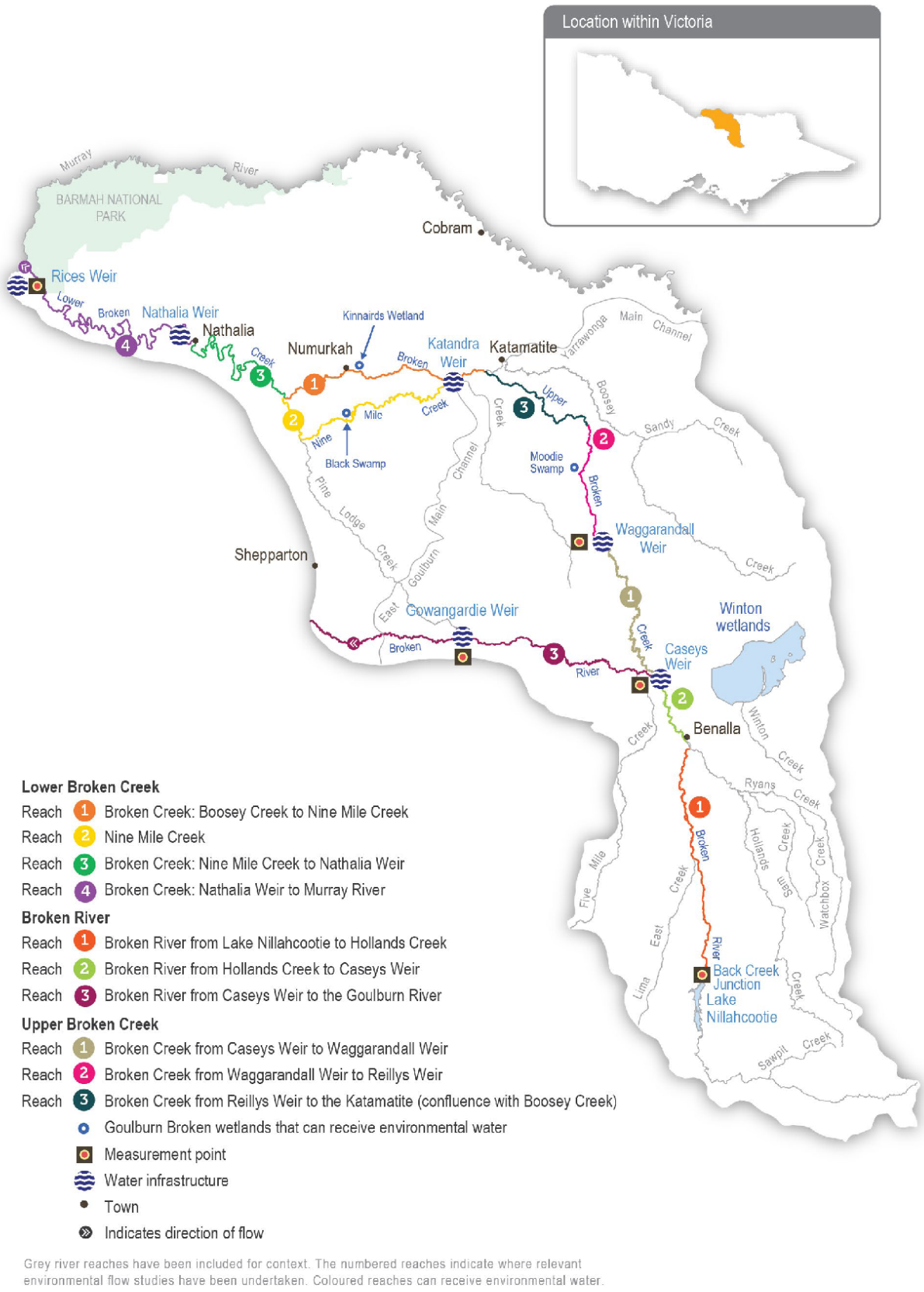
Figure 5.5.1 The Broken system



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

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Environmental values

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

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

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

Environmental watering objectives in the Broken River and upper Broken Creek

Icon	Environmental objectives in the Broken River and upper Broken Creek
	Maintain native fish populations
	Turn over bed sediments and scour around large wood to maintain in-channel habitat diversity
	Maintain platypus populations
	Maintain in-stream vegetation
	Maintain a wide range and high biomass of waterbugs to break down dead organic matter and support the river's food web
	Maintain water quality

Traditional Owner cultural values and uses

Traditional Owners value implementing more natural flow regimes in the landscape's waterways and wetlands as a way of caring for Country, supporting culturally important plants and providing opportunities to practise culture.

Goulburn Broken CMA consulted with the Yorta Yorta Nation Aboriginal Corporation for upper Broken Creek and the Broken River downstream of Benalla and the Taungurung Land and Waters Council for the Broken River upstream of Benalla.

The Taungurung Land and Waters Council plan to assess cultural values and objectives for the Broken River through healthy Country assessments like Aboriginal Waterway Assessments. These will assist the Taungurung Land and Waters Council in identifying more specific cultural objectives for the system in future. The Taungurung Land and Waters Council has been part of the Broken system advisory group meetings since 2018 and is continuing to work with Goulburn Broken CMA to identify cultural objectives and develop culturally informed recommendations for water for the environment in the Broken system. Water for the environment in the Broken system supports the health of cultural values and landscapes, including intangible cultural heritage, valued species and traditional food and medicine plants.

The Yorta Yorta Nation Aboriginal Corporation has provided the following statement about the cultural values of the Broken River and upper Broken Creek:

> "The Broken River (and upper Broken Creek) hold many cultural values. Common reed contained within the slack water provides important material for tools while also providing refuge for culturally important fish species (large- and small-bodied). The river also has significant stands of old-growth river red gum containing important habitat and exhibiting scars made from carving out canoes and coolamons."

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Social, recreational and economic values and uses

In planning the potential watering actions in Table 5.5.1, Goulburn Broken CMA considered how environmental flows could support values and uses, including:

- water-based recreation (such as canoeing, fishing, kayaking and swimming)
- riverside recreation (such as birdwatching, bushwalking, camping, duck hunting and picnicking)
- amenity: green and blue spaces are important to the community for wellbeing and mental health due to the otherwise dry environment
- community events and tourism (such as markets around Benalla Lake)
- socio-economic benefits (such as maintaining the volume of water in the lower sections to optimise the efficiency of deliveries of consumptive water, maintain water quality for irrigation, stock and domestic use and support terrestrial birds that help control agricultural pests).

Recent conditions

Rainfall across the Broken River catchment during 2021-22 was slightly above the long-term average, and January rainfall was the highest recorded since 2011. Lake Nillahcootie filled and spilled in August 2021, and the lake remained at full capacity until mid-November. Several natural freshes ranging from 500 ML per day to 3,500 ML per day occurred in the Broken River between July and February, and a bankfull flow of 5,000 ML per day occurred in early September. Upper Broken Creek also had two natural overbank flow events in late January. Allocations against high- and low-reliability water shares in the Broken system reached 100 percent by September and October, respectively. About 2.6 GL of water for the environment from VEWH and CEWH entitlements in the Goulburn was traded into the Broken system to meet demands in upper Broken Creek and Moodie Swamp: subsection 5.5.3 Broken wetlands has more information about this.

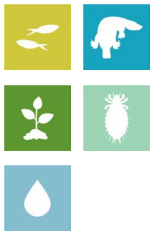
Deliveries of water for the environment for the Broken system were managed in line with an average climate scenario during 2021-22. Planned watering actions for Broken River were largely met by natural flow and operational releases, while planned watering actions for upper Broken Creek were only partially met. Water for the environment was used to help meet low flow requirements in upper Broken Creek during summer and autumn and to deliver a fresh to try to minimise the impact of a hypoxic blackwater event that was caused by the January overbank flow. The fresh helped to improve oxygen levels in upper Broken Creek, but not before some fish died (mainly European carp and a small number of Murray cod).

Scope of environmental watering

Table 5.5.1 describes the potential environmental watering actions in 2022-23, their expected watering effects (that is, the intended physical or biological effects of the watering action) and the longer-term environmental objective(s) they support. Each environmental objective relies on one or more potential environmental watering actions and their associated physical or biological effects.

Table 5.5.1 Potential environmental watering actions, expected watering effects and associated environmental objectives for the Broken River and upper Broken Creek

Potential environmental watering action	Expected watering effects	Environmental objectives
Upper Broken Creek (reach 1)		
Winter low flow (1-10 ML/day during June to August)	• Maintain aquatic habitat and connections between weir pools for native fish and platypus • Inundate benthic surfaces and large wood located at the bottom of the channel, which serves as habitat for waterbugs • Maintain water quality and oxygen levels for native fish, platypus and waterbugs	
Spring low flow (1-10 ML/day during September to November)		
Summer low flow (1-5 ML/day during December to February)		
Autumn low flow (1-5 ML/day during March to May)		
Summer/autumn fresh (one fresh of 50-100 ML/day for 10 days during December to May)	• Flush pools to improve their water quality and increase oxygen levels	

Potential environmental watering action	Expected watering effects	Environmental objectives
Broken River (reach 1, 2 and 3)		
Winter low flow (15-30 ML/day during June to August)	• Maintain habitat for in-stream and fringing vegetation, and prevent terrestrial vegetation from colonising the stream bed • Maintain riffles, pools and slackwater to provide diverse hydraulic habitat for native fish, aquatic plants, platypus and waterbugs • Maintain water quality and oxygen levels for native fish, platypus and waterbugs	
Spring low flow (15-30 ML/day during September to November)		
Summer low flow (15-30 ML/day during December to May)		
Autumn low flow (15-30 ML/day during March to May)		
Summer/autumn fresh (one fresh of 400-500 ML/day for two to five days during December to May)	• Scour sediments around large wood, turn over bed sediments, replenish biofilms and maintain macrophyte habitat • Provide flow cues to stimulate native fish to breed and migrate • Maintain longitudinal connectivity for native fish passage	

Scenario planning

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

There are two sets of watering actions: one for upper Broken Creek and another for the Broken River. Delivering flow to upper Broken Creek is a higher priority, because upper Broken Creek has no inflows from tributaries and is more reliant on operational water deliveries and water for the environment. The potential watering actions for upper Broken Creek require less water than the potential watering actions for Broken River, and any environmental flows delivered to upper Broken Creek will pass through reaches 1 and 2 of the Broken River, where they will provide some environmental benefit.

All potential watering actions in the Broken and upper Broken Creek are required across all climatic scenarios, but there is insufficient water for the environment to meet most of them, and no environmental allocations are expected for the Broken system in 2022-23 under a drought scenario. The VEWH may elect to trade water into the system to meet high priority potential watering actions if a trade opportunity is available.

The main objective of environmental flows in the upper Broken Creek is to maintain low flow throughout the year so as to maintain water quality and habitat for native fish, platypus and waterbugs. Maintaining adequate flow and connectivity is particularly important during spring, when native fish, platypus, waterbugs and aquatic vegetation are most active and productive. Water for the environment will likely be prioritised for spring low flow under a dry climate scenario, and greater allocations under average and wet scenarios may be used to supplement low flow at any time of year as needed. Summer/autumn freshes may be needed to help mitigate hypoxic blackwater events. The natural high flow that causes hypoxic blackwater events is most likely under average or wet climatic conditions. Goulburn Broken CMA will monitor conditions and may limit the use of water for the environment for low flow during low-risk periods to enable them to deliver emergency freshes if needed.

Year-round low flow is needed to support the Broken River environmental objectives, but there is little capacity to influence these with environmental flows, especially under drought and dry climate scenarios. Operational deliveries and natural tributary inflows will likely meet a large proportion of the recommended flow in the Broken River under average and wet climate scenarios, and water for the environment may be used to supplement any of the recommended low flows or summer/autumn freshes if needed.

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

Planning scenario	Drought	Dry	Average	Wet
Expected river conditions	• No unregulated flow in Broken River or upper Broken Creek • Low and cease-to-flow events are probable throughout the year in all reaches	• Low, unregulated flow in Broken River and none in upper Broken Creek • Low and cease-to-flow events are possible throughout the year in all reaches	• High winter/spring flow in Broken River • Some unregulated flow in upper Broken Creek	• High winter/spring flow in Broken River • Unregulated flow in upper Broken Creek with some winter/spring freshes
Expected availability of water for the environment	• 0 ML	• 226 ML	• 647 ML (plus available trade opportunity up to 1,500 ML)	• 647 ML (plus available trade opportunity up to 1,500 ML)
Upper Broken Creek (targeting reach 1)				
Potential environmental watering – tier 1 (high priorities)	**Tier 1a (can be achieved with predicted supply)**			
	• N/A	• Spring low flow	• Winter low flow • Spring low flow • Summer low flow • Autumn low flow • Summer/autumn fresh	• Winter low flow • Spring low flow • Summer low flow • Autumn low flow • Summer/autumn fresh
	Tier 1b (supply deficit)			
	• Winter low flow • Spring low flow • Summer low flow • Autumn low flow • Summer/autumn fresh	• Winter low flow • Summer low flow • Autumn low flow • Summer/autumn fresh	• N/A	
Potential environmental watering – tier 2 (additional priorities)	• N/A			
Broken River (targeting reach 1, 2 and 3)				
Potential environmental watering – tier 1 (high priorities)	**Tier 1a (can be achieved with predicted supply)**			
	• N/A		• Winter low flow • Spring low flow • Summer low flow • Autumn low flow • Summer/autumn fresh	• Winter low flow • Spring low flow • Summer low flow • Autumn low flow • Summer/autumn fresh
	Tier 1b (supply deficit)			
	• Winter low flow • Spring low flow • Summer low flow • Autumn low flow	• Winter low flow • Spring low flow • Summer low flow • Autumn low flow • Summer/autumn fresh	• N/A	

Planning scenario	Drought	Dry	Average	Wet
Potential environmental watering – tier 2 (additional priorities)	• N/A			
Possible volume of water for the environment required to achieve objectives	• 0 ML (tier 1a) • 6,676 ML (tier 1b)	• 226 ML (tier 1a) • 11,724 ML (tier 1b)	• 2,147 ML (tier 1a)[1] • 0 ML (tier 1b)	• 490 ML (tier 1a)[1] • 0 ML (tier 1b)
Priority carryover requirements for 2023-24	• N/A			

1 This assumes water available made through trade opportunity.

5.5.2 Lower Broken Creek

System overview

The Lower Broken Creek system is within Yorta Yorta Country, and their cultural connection is evident throughout the landscape. The lower Broken Creek system includes the section of Broken Creek that flows from the confluence of Boosey Creek near Katamatite to the Murray River; and Nine Mile Creek, which is an anabranch of lower Broken Creek that flows from the East Goulburn Main Channel to below Numurkah.

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

Regulated water is delivered to lower Broken Creek from the Goulburn and Murray systems via the irrigation channel network. Lower Broken Creek is operated separately from upper Broken Creek and Broken River, which are both supplied from Lake Nillahcootie on upper Broken River.

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

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

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 Murray-Darling rainbowfish.

Sections of lower Broken and Nine Mile creeks have been reserved as state park and natural feature reserves. The associated floodplain and wetland habitats support box-dominated grassy woodland communities and numerous species of state and national conservation significance, including river swamp wallaby grass and the Australasian bittern.

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Environmental watering objectives in lower Broken Creek

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

Traditional Owner cultural values and uses

Goulburn Broken CMA consulted with the Yorta Yorta Nation Aboriginal Corporation during the planning of deliveries of water for the environment in lower Broken Creek. The following cultural values were identified for lower Broken Creek in 2021. The YYNAC were again consulted on this for the 2022-23 watering season.

> "The Broken Creek holds many cultural values. Common reed contained within the slack water provides important material for tools while also providing refuge for culturally important fish species (large and small-bodied). The creek also has significant stands of old growth river red gum containing important habitat and exhibiting scars made from carving out canoes and coolamons."

The Yorta Yorta Nation Aboriginal Corporation continues to pursue the Yorta Yorta People's inherent rights to water for Country to improve their spiritual, cultural, environmental, social and economic needs, in line with the *Yorta Yorta Whole-Of-Country Plan 2021-2030*.

The environmental objectives in lower Broken Creek seasonal watering proposal are supported by Yorta Yorta and align with their values of caring for Country. Flows have been specifically targeted to support in-stream vegetation and native fish, along with other aquatic plants and animals. Goulburn Broken CMA will continue to work with Yorta Yorta people to identify how the management of water for the environment can best support water for their Country, enhancing cultural values.

The Yorta Yorta Nation Aboriginal Corporation has raised concerns about flow regulation in all their waterways, which is affecting their Country and cultural knowledge.

Social, recreational and economic values and uses

In planning the potential watering actions in Table 5.5.3, Goulburn Broken CMA considered how environmental flows could support values and uses, including:

- water-based recreation (such as canoeing, fishing, game hunting and kayaking)
- riverside recreation and amenity (such as aesthetic and amenity values that are particularly important for the community's mental health and wellbeing during dry periods and passive recreation)
- community events and tourism
- socio-economic benefits (such as consumptive water users, Goulburn-Murray Water irrigators and diverters and Goulburn Valley Water customers).

Recent conditions

The Goulburn Broken region experienced average to above-average rainfall and temperatures throughout most of 2021-22 as a La Niña weather event influenced climate conditions across eastern Australia. Winter/spring rainfall in the Broken catchment provided unregulated inflows from upper Broken Creek to the south and Boosey Creek to the east. These were the highest unregulated inflows to lower Broken Creek since 2016. Allocations against high-reliability water entitlements in the Goulburn and Murray storages that supply lower Broken Creek reached 100 percent by October 2021, and low-reliability entitlements in the Murray system reached 100 percent by February 2022.

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Deliveries of water for the environment in lower Broken Creek were managed in line with an average climate scenario in 2021-22. IVTs and Murray Bypass flows (which often meet environmental flow targets) were not delivered via lower Broken Creek throughout spring, summer and autumn due to high, unregulated flow in the Murray River. This meant greater volumes of water for the environment were required to achieve environmental objectives. Planned watering actions were largely achieved between mid-August 2021 and mid-May 2022, but maintenance works on the Yarrawonga Main Channel and the East Goulburn Main Channel during July 2021 meant the winter low-flow target of 40 ML per day was not met. Fishways were also closed during this period to maintain water levels in the weir pools, and other sections of the creek contracted to a series of shallow pools, which provided limited habitat for native fish and platypus. This was the fourth consecutive year that maintenance works during the irrigation shut-down period have limited deliveries of water for the environment in lower Broken Creek.

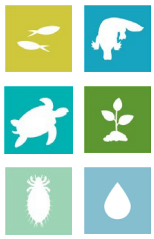
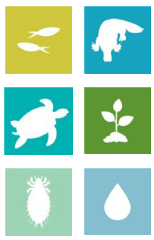
Oxygen levels in lower Broken Creek dropped below the critical level of 4 mg/L during hot weather on four occasions in summer. Environmental flows were increased to 350 ML per day under emergency watering provisions to reduce stress on resident fish populations. Water for the environment was also used to dilute a hypoxic blackwater event that was caused by a heavy rain event in late January.

There is little ecological monitoring in lower Broken Creek, but members of the Broken Environmental Water Advisory Group and other community members have reported a marked improvement in water quality since deliveries of water for the environment started in 2010-11. There are also anecdotal reports the native fish population has improved. Some monitoring in lower Broken Creek is planned during 2022 to inform the Goulburn to Murray Trade Rule Review. The monitoring will investigate how different flow patterns affect vegetation and erosion rates on the riverbank, and it will inform future creek operations.

Scope of environmental watering

Table 5.5.3 describes the potential environmental watering actions in 2022-23, their expected watering effects (that is, the intended physical or biological effects of the watering action) and the longer-term environmental objectives they support. Each environmental objective relies on one or more potential environmental watering actions and their associated physical or biological effects.

Table 5.5.3 Potential environmental watering actions, expected watering effects and associated environmental objectives for lower Broken Creek

Potential environmental watering action	Expected watering effects	Environmental objectives
Winter low flow (20-40 ML/day during May to August)[1]	• Provide native fish with passage through fish ladders • Provide suitable foraging habitat for platypus and rakali (water rats), and support the conditioning of females in preparation for the breeding season • Provide habitat for turtles, including protection from exposure during their winter dormancy • Provide flowing-water habitat and avoid winter drying of weir pools for fish, vegetation, waterbugs, platypus and turtles • Maintain water over submerged aquatic plants so they are protected from drying and frost • Reduce the stagnation of weir pools	
Spring/summer/autumn low flow (70-250 ML/day in reaches 1 and 2 and 200-450 ML/day in reaches 3 and 4 during August to May)	• Provide habitat for native fish, platypus, rakali, turtles and waterbugs • Support the movement and recruitment of fish • Maintain oxygen levels in summer • Additional benefits when delivered from December to February (at 250-450 ML/day): - mobilise azolla and increase oxygen levels during high-risk periods	
Winter/spring fresh(es) (one to three freshes of 300-450 ML/day for one to two weeks during July to November)	• Flush and mobilise azolla if it has accumulated to maintain water quality • Trigger the movement and spawning of fish • Encourage the germination and growth of littoral and in-stream vegetation • Reduce the stagnation of weir pools	

1 This flow may be difficult to achieve when channel maintenance work is being completed. If maintenance work is required, waterway managers will work with the storage manager to minimise impacts where possible. Possible mitigation actions include closing fishways to maintain water in weir pools and scheduling works to minimise the duration of impacts on flow.

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Scenario planning

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

The high degree of regulation in the lower Broken Creek system means flow patterns in the lower Broken and Nine Mile creeks are the same under all climate scenarios. Water for the environment in the lower Broken Creek system is primarily used to guard against reduced flow during the non-irrigation season.

Potential watering actions under all climate scenarios include maintaining flow above 40 ML per day outside the irrigation season, ameliorating sudden fluctuations in irrigation demand during the irrigation season and delivering spring freshes to trigger fish movement or flush excessive accumulations of azolla. Goulburn Broken CMA will monitor water quality throughout the year, and it may increase flow to the upper end of the recommended range in Table 5.5.3 if oxygen levels drop below 4.0 mg/L. The total volume of water for the environment that will be needed to achieve planned watering actions in 2022-23 will vary depending on operational deliveries (including IVTs) and the sizes and durations of any unregulated flow events. A carryover target of 5,000 ML applies under all climate scenarios to ensure minimum low flow and a small fresh can be delivered early in 2023-24.

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

Planning scenario	Drought	Dry	Average	Wet
Expected river conditions	• No unregulated flow	• Some unregulated flow in winter • No unregulated flow throughout the irrigation season (mid-August to May) • No diversion of unregulated Murray River flow is available	• Unregulated flow in winter/spring • Unregulated flow is unlikely from October to May • Diversion of unregulated Murray River flow is available from mid-August to October	• Unregulated flow is likely in winter/ spring • Unregulated flow is possible from November to May • Diversion of unregulated Murray River flow available from mid-August to November
Potential environmental watering – tier 1 (high priorities)[1]	• Winter low flow • Spring/summer/autumn low flow • Winter/spring freshes			
Possible volume of water for the environment required to achieve objectives	• 80,000 ML			
Priority carryover requirements for 2023-24	• 5,000 ML			

1 Tier 1 potential environmental watering for lower Broken Creek is not classified as tier 1a or 1b because the water available for use is shared across various systems, and it is not possible to reliably determine the supply specifically available for lower Broken Creek.

5.5.3 Broken wetlands

System overview

Of some 2,000 natural wetlands in the Goulburn Broken area, only three in the Broken catchment have infrastructure that allows them to receive environmental water: Black Swamp, Kinnairds Wetland and Moodie Swamp.

These wetlands are on Country of the Yorta Yorta People, whose knowledge is evident throughout the landscape. Kinnairds Wetland and Black Swamp are red gum swamps near Numurkah. Moodie Swamp is a cane grass wetland adjacent to upper Broken Creek at Waggarandall that provides excellent breeding habitat for brolga.

The water regimes of these wetlands are influenced by their position in the landscape. The development and operation of the Shepparton and Murray Valley irrigation districts have changed the natural flow paths and the timing, frequency, volume and duration of natural flooding to these and other wetlands in the region. Existing irrigation system infrastructure enables water for the environment to be delivered to the three nominated wetlands, but under existing agreements, irrigation deliveries have priority within the channel system. This limits the volume of water that can be delivered to the wetlands. The VEWH, waterway managers and storage managers adjust the timing and rate of environmental deliveries where possible to optimise environmental outcomes within the current system constraints.

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Environmental values

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

Environmental watering objectives in the Broken wetlands

Icon	Environmental objectives in the Broken wetlands
	Maintain or improve the cover, diversity, recruitment/regeneration and growth of native wetland plant species, consistent with ecological vegetation class benchmarks Reduce the cover and diversity of exotic plant species Maintain populations of rigid water-milfoil
	Provide breeding habitat for waterbirds Provide feeding and roosting habitat for waterbirds
	Provide breeding habitat for frogs

Traditional Owner cultural values and uses

Goulburn Broken CMA consults with the Yorta Yorta Nation Aboriginal Corporation when planning deliveries of water for the environment in the Broken system.

Currently, water for the environment can only be delivered to Broken wetlands in Yorta Yorta Country. The Yorta Yorta Nation Aboriginal Corporation and the CMA are working to ensure that planned watering actions at Black Swamp, Kinnairds Wetland and Moodie Swamp align with the conservation and protection of cultural sites and allow for connection to Country and the establishment of strong linkages. The Yorta Yorta Nation Aboriginal Corporation has been involved in planning through online meetings and on-Country visits and by providing content for, reviewing and endorsing the Broken wetlands seasonal watering proposal.

Increasing the involvement of Traditional Owners in the planning and management of water for the environment and ultimately providing opportunities to progress towards self-determination within the environmental watering program is a core commitment of the VEWH and its agency partners. This is reinforced by a range of legislative and policy commitments, including the *Water Act 1989*, the Victorian Aboriginal Affairs Framework, the 2016 *Water for Victoria* and in some cases, agreements under the *Traditional Owner Settlement Act 2010*.

Where Traditional Owners are more deeply involved in the planning and/or delivery of environmental flows for a particular site, their contribution is acknowledged in Table 5.5.5 with an icon. The use of this icon is not intended to indicate that these activities are meeting all the needs of Traditional Owners but is incorporated in the spirit of valuing their contribution and indicating progress towards deeper involvement.

	Watering planned and/or delivered in partnership with Traditional Owners to support cultural values and uses

Black Swamp and Kinnairds Wetland have significant diversity within the landscape, and multiple varieties of nardoo (a food source), native grasses (such as old man weed and sneezeweed, which have medicinal uses) and sedges and rushes (used for basket weaving) are in the area. Each of the sites, including Moodie Swamp, supports a wide array of bird life and other animals that provide a variety of cultural values. At Black Swamp, there is evidence of cooking mounds around the perimeter, and there are basket weaving sedges at Moodie Swamp.

Traditional Owner icons in the tables below indicate which proposed watering actions support these values.

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Social, recreational and economic values and uses

In planning the potential watering actions in Table 5.5.5, Goulburn Broken CMA considered how environmental flows could support values and uses, including:

- water-based recreation (such as canoeing)
- riverside recreation and amenity (such as birdwatching, camping, picnicking, photography and walking)
- community events and tourism (such as community gatherings at Kinnairds Wetland and the Walk and Squawk event)
- socio-economic benefits (such as tourism, which is a large contributor to the local economy).

Recent conditions

Rainfall in the Broken catchment during 2021-22 was close to the long-term average, and significant rain events in June 2021, September 2021 and January 2022 contributed some local run-off to the region's wetlands. Allocations against high-reliability water shares in the Goulburn, Murray and Broken systems reached 100 percent by mid-October 2021, which meant there was sufficient supply to meet planned deliveries of water for the environment.

Deliveries of water for the environment for the Broken wetlands were managed in line with an average climate scenario in 2021-22, and all planned watering actions were fully achieved through a combination of water for the environment and natural inflows. All three wetlands are ephemeral systems that rely on wet and dry phases to support ecological processes.

For the second year in a row, Kinnairds Wetland and Black Swamp were filled in spring and allowed to draw down and dry by summer. Moodie Swamp was originally going to be filled in autumn 2022, but natural inflows during winter 2021 attracted brolga to the site, so deliveries of water for the environment were brought forward to spring 2021 to encourage the birds to nest and breed. Specific responses to deliveries of water for the environment in 2021-22 included the vigorous growth of newly planted river red gum saplings at Black Swamp, spotted marsh frogs breeding at Kinnairds Wetland and brolga feeding and courting at Moodie Swamp. Kinnairds Wetland and Black Swamp dried by the end of 2021-22, but Moodie Swamp still held some water.

Scope of environmental watering

Table 5.5.5 describes the potential environmental watering actions in 2022-23, their expected watering effects (that is, the intended physical or biological effects of the watering action) and the longer-term environmental objectives they support. Each environmental objective relies on one or more potential environmental watering actions and their associated physical or biological effects.

Table 5.5.5 Potential environmental watering actions, expected watering effects and associated environmental objectives for the Broken wetlands

Potential environmental watering action	Expected watering effects	Environmental objectives
Black Swamp (partial fill in autumn and top up as required)	• Promote the growth of planted river red gum saplings and improve the condition of Red Gum Swamp Ecological Vegetation Class (EVC) vegetation, including river swamp wallaby grass • Provide habitat and food resources to support waterbirds and frogs	
Kinnairds Wetland (fill in autumn and top up as required)	• Promote the growth and improve the condition of Red Gum Swamp EVC and Plains Grassy Wetland EVC vegetation, including rigid water-milfoil • Provide habitat and food resources to support waterbirds and frogs	

Scenario planning

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

A partial fill of Black Swamp and a complete fill of Kinnairds Wetland in autumn 2023 are high priorities across all climate scenarios. The timings of the proposed fills will allow the wetlands to experience a slightly longer dry phase than they have in recent years. This will enhance nutrient cycling processes without exceeding the dry tolerance interval of red gum swamp vegetation communities. These watering actions may be brought forward to spring 2022 if wet conditions naturally inundate the beds of the wetlands and disrupt dry-phase ecological processes.

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Moodie Swamp was still holding water in autumn 2022. Active watering is not planned in 2022-23 to allow it to complete a dry-phase cycle.

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

Planning scenario	Drought	Dry	Average	Wet
Expected river conditions	• Catchment run-off and natural flow into the wetlands are highly unlikely	• Catchment run-off and natural flow into the wetlands are unlikely	• Some catchment run-off and natural flow into some of the wetlands are likely, particularly in winter/spring	• Catchment run-off and natural flow into the wetlands may significantly contribute to water levels in the wetlands, particularly in winter/spring
Potential environmental watering – tier 1 (high priorities)	• Black Swamp • Kinnairds Wetland	• Black Swamp • Kinnairds Wetland	• Black Swamp • Kinnairds Wetland	• Black Swamp • Kinnairds Wetland
Potential environmental watering – tier 2 (additional priorities)	• N/A			
Possible volume of water for the environment required to achieve objectives	• 680 ML (tier 1)	• 680 ML (tier 1)	• 680 ML (tier 1)	• 340 ML (tier 1)

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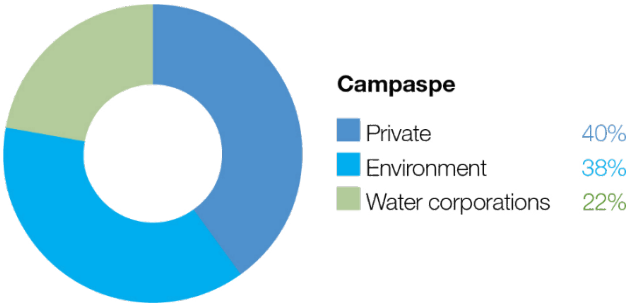
5.6 Campaspe system

Waterway manager – North Central Catchment Management Authority

Storage manager – Goulburn-Murray Water

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

Proportions of water entitlements in the Campaspe basin held by private users, water corporations and environmental water holders on 30 June 2020



The Campaspe system includes the Campaspe River and Coliban River.

5.6.1 Campaspe River

System overview

Natural inflows in the upper Campaspe River catchment are harvested into Lake Eppalock, which is located near the townships of Axedale and Heathcote. The main tributaries of the Campaspe River are the Coliban River, McIvor and Wild Duck creeks above Lake Eppalock and Mount Pleasant, Forest and Axe creeks below Lake Eppalock (Figure 5.6.1).

Below Lake Eppalock, the major in-stream structure is the Campaspe Weir, which was built to divert water to the Campaspe Irrigation District. It is no longer used for water diversion but is a barrier to fish migration. Higher flows spill over the weir. The Campaspe Siphon, just below Rochester, is part of the Waranga Western Channel, which carries water from the Goulburn system to western Victoria. Water can be released from the Waranga Western Channel into the lower reaches of the Campaspe River, but the siphon is another barrier to fish migration when there is low-to-moderate flow.

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

Water for the environment is released from Lake Eppalock to support aquatic plants and animals in and along the Campaspe River. It can be supplemented by water for the environment delivered via the Waranga Western Channel at the Campaspe Siphon, which provides important flexibility to meet environmental demands in reach 4. Water for the environment is primarily used in the Campaspe River to improve the magnitude and variability of flow during winter and spring, but it is also used to deliver critical flow in summer and autumn that is not met or exceeded by operational deliveries. Primary flow measurement points are at Barnadown (reach 2) and below the Campaspe Siphon (reach 4).

Goulburn-Murray Water transfers operational water from Lake Eppalock or through Waranga Western Channel to customers in the Murray River and to downstream storages (such as Lake Victoria). These inter-valley transfers (IVTs) usually occur in summer and autumn and, depending on the rate of delivery, can either support or compromise environmental flow objectives. High IVT flows delivered at a time when the Campaspe River would naturally have low flow may reduce the amount of suitable habitat for juvenile fish, which rely on protected, shallow areas of water near the edge of the river channel. Sustained high IVT flows in summer can also drown recruiting streamside vegetation. Storage managers and North Central CMA have been working cooperatively to enhance the positive effects and limit the negative effects of IVTs on native plants and animals in the Campaspe River. For example, IVTs are sometimes delivered in a pattern that meets summer low-flow and fresh requirements, thereby reducing demand on the environmental entitlement. IVTs have also been released in a pattern to support native fish migration from the Murray River into reach 4 of the Campaspe River without affecting delivery to downstream users.

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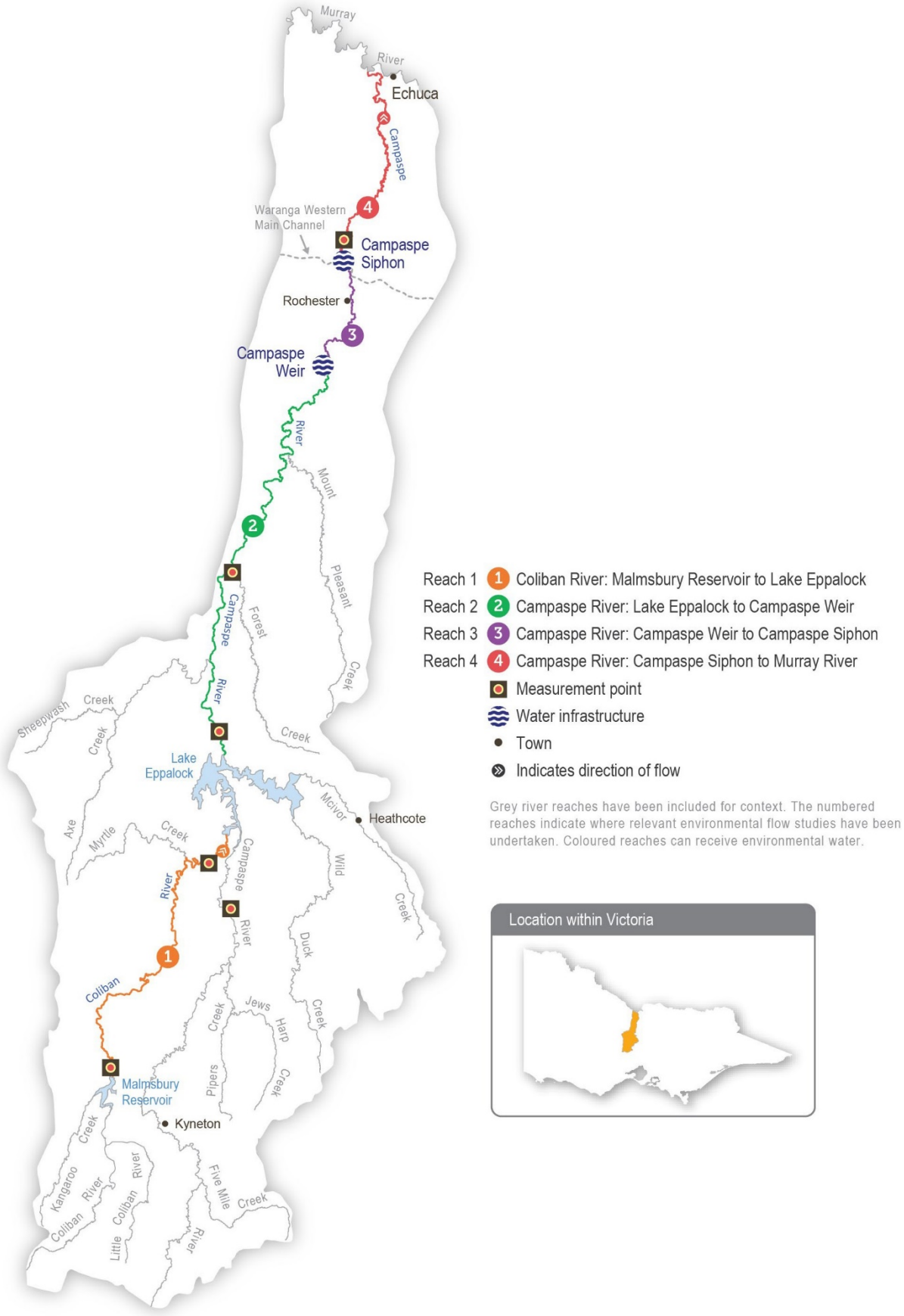
Figure 5.6.1 The Campaspe system



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Environmental values

The Campaspe River below Lake Eppalock provides important habitat for several native fish species, including Murray cod, silver perch, golden perch, Murray-Darling rainbowfish and flat-headed gudgeon. Murray-Darling rainbowfish were presumed lost from the system during the Millennium drought, but since 2011, they have been recorded at many sites on the Campaspe River and are now abundant below Elmore. Environmental flows help native fish migrate and disperse throughout the Campaspe system.

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

Environmental watering objectives in the Campaspe River

Icon	Environmental objectives in the Campaspe River
	Protect and increase populations of native fish Facilitate recolonisation by native fish species (including trout cod and blackfish) that have been presumed lost
	Enhance the channel form and features, including deep pools and benches Maintain the condition of suitable substrate to maintain ecosystem processes Engage floodrunners, distributary channels, anabranches and backwaters
	Protect the resident platypus population
	Maintain adult river red gums and increase the recruitment of immature trees Maintain the extent and increase the diversity of streamside vegetation Increase the extent of in-stream aquatic plants
	Increase the diversity and biomass of waterbugs
	Maintain water quality in deep pools and prevent stratification in summer Reduce the risk of hypoxic blackwater events in summer

Traditional Owner cultural values and uses

In planning for environmental flows in the Campaspe River, North Central CMA has worked with Dja Dja Wurrung Clans Aboriginal Corporation (trading as DJAARA), Taungurung Land and Waters Council and Yorta Yorta Nation Aboriginal Corporation to discuss how cultural values and uses can be supported by water for the environment and the importance of Traditional Owner involvement in management.

Despite the significant impacts of the Covid-19 pandemic on the ability to conduct face-to-face engagement on 2022-23 watering priorities, all three Corporations reviewed the watering priorities and discussions were had. These included:

1. discussions between the DJAARA Kapa Gatjin (water advisory) Group and North Central CMA about 2022-23 priorities, including opportunities for Djaara (the Dja Dja Wurrung people) to participate in field visits and monitoring. In 2020, Kapa Gatjin expressed their aspirations and environmental objectives for the Campaspe River in a more general sense and highlighted the significance of native fish, turtles, medicine plants and pest control. I Dja Dja Wurrung will continue to build on traditional ecological knowledge to further inform seasonal watering proposals and plans and will play a greater role in the administering of environmental water.
2. discussions between Taungurung Land and Waters Council's Baan Ganalina Advisory Group and North Central CMA about 2022-23 priorities, including opportunities for Dja Dja Wurrung field visits and monitoring. This included discussions at the 2022 North Central CMA River Tour. In late 2019, Baan Ganalina highlighted the importance of native fauna and identified the importance of overstorey, mid-layer and aquatic vegetation in creating healthy habitat and preventing flows that might erode or damage cultural sites.
3. discussions between the Yorta Yorta Nation Aboriginal Corporation Consultation group and Goulburn Broken, North East and North Central CMAs, where CMA activities on Country are discussed. At these meetings in the past, Yorta Yorta Traditional Owners have raised concerns regarding the impacts of groundwater extraction on river flows and gold mining in the Campaspe Valley, and support flows that will mitigate the impacts of consumptive water delivery over summer and provide conditions to improve habitat for platypus breeding.

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Social, recreational, and economic values and uses

In planning the potential watering actions in Table 5.6.1, North Central CMA considered how environmental flows could support values and uses, including:

- water-based recreation (such as canoeing, kayaking, fishing and water sports)
- riverside recreation and amenity (such as birdwatching, bushwalking, camping, cycling, duck hunting and picnicking)
- community events and tourism (such as visitors travelling to canoe and kayak on the river)
- socio-economic benefits (such as diversions for irrigation, domestic and stock uses; local and regional economic benefits from increased visitation; ecosystem services [such as carbon storage, groundwater recharge and water-quality regulation]; lower salinity management costs and blackwater and blue-green algae risks for landholders; and contributions to community enjoyment, health and recuperation).

If the timing or management of planned environmental flows may be modified to align with a community benefit, this is acknowledged in Table 5.6.1 with the following icon.

Watering planned to support peaks in visitation (e.g. camping or other public activities on long weekends or school holidays)

There are many places along the Campaspe River where visitors like to camp. Aysons Reserve is a popular camping site near Elmore, and it draws hundreds of campers during school holiday periods. Where possible, freshes are delivered outside of peak visitation periods (such as the March and April long weekends) to ensure the flow is not too high for campers and water-related activities.

Recent conditions

Rainfall in the Campaspe system in 2021-22 was close to the long-term average, although spring 2021 was wetter than average. Maximum temperatures across the system were slightly above the long-term average. Allocations against high-reliability water shares rose from 14 percent at the start of July to 100 percent in September, but there were no allocations against low-reliability water shares. Available allocations were not enough to meet demands for environmental flows, so 4 GL of water for the environment from the Goulburn was traded into the Campaspe system to support 2021-22 potential watering actions.

Deliveries of water for the environment for the Campaspe system were managed in line with an average climate scenario throughout 2021-22. Most planned watering actions were achieved through a combination of environmental flows, natural flows and operational deliveries. Extremely low demand for IVTs from the Campaspe River meant more water for the environment was needed to achieve the target low flow and freshes from late spring to autumn, compared to previous seasons. Two of the planned summer/autumn freshes were used to help mitigate low-oxygen conditions that were detected during hot weather in mid-December and late January.

The only planned watering action not delivered in 2021-22 was a second winter/spring fresh. Winter/spring freshes aim to flush organics from the riverbanks and low benches to reduce the risk of blackwater events in summer, support river red gums and prevent terrestrial grasses from colonising the river banks. The Campaspe River has received most of its recommended flow regime over the last two years, and the first fresh delivered in September 2021 met its objectives. The second fresh was not delivered to avoid unnecessarily disturbing Murray cod during their nesting season. North Central CMA is working with fish ecologists to determine the circumstances under which future freshes should be delivered during the Murray cod nesting season.

Regular fish surveys conducted as part of the Victorian Environmental Flows Monitoring and Assessment Program (VEFMAP) demonstrate that native fish communities in the Campaspe River have steadily improved since 2014. VEFMAP has also reported better streamside and in-stream vegetation in sections of the river where livestock are excluded. Watering actions that aim to expose mudflats during autumn to promote native vegetation recruitment in these areas may be trialled in 2022-23.

Scope of environmental watering

Table 5.6.1 describes the potential environmental watering actions in 2022-23, their expected watering effects (that is, the intended physical or biological effects of the watering action) and the longer-term environmental objective(s) they support. Each environmental objective relies on one or more potential environmental watering actions and their associated physical or biological effects.

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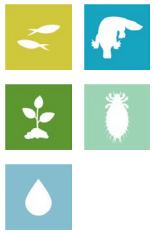
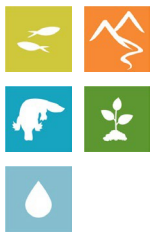
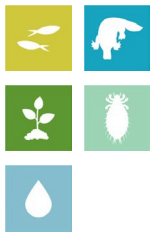
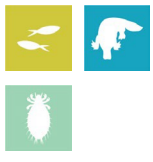
Table 5.6.1 Potential environmental watering actions, expected watering effects and associated environmental objectives for the Campaspe River

Potential environmental watering action	Expected watering effects	Environmental objectives
Campaspe River (targeting reach 4)		
Winter/spring low flow (50-200 ML/day during June to November)	• Increase longitudinal connectivity to allow native fish to access new habitats • Provide foraging opportunities across a wide range of habitats for female platypus to develop fat reserves before breeding • Maintain water quality by preventing pools from stratifying • Discourage terrestrial plants from colonising the lower sections of the riverbank and low benches in the channel • Maintain soil moisture in the riverbank to water established river red gums and woody shrubs • Help establish littoral vegetation[1] • Provide a variety and large abundance of habitats for high macroinvertebrate productivity supporting food webs • Greater-magnitude flows will facilitate: - long-distance movement by male platypus, especially in the August to October breeding season - greater movement of large-bodied native fish	
Winter/spring fresh(es) (one to two[2] freshes 1,000-1,800 ML/day for two to seven days during June to November)	• Flush accumulated leaf litter from the banks and low benches to reduce the risk of blackwater events during high river flow in summer • Maintain soil moisture for established river red gum and woody shrubs (such as bottlebrush and tea tree) • Provide sufficient velocity to scour accumulated sediment from pools and scour biofilms • Maintain connectivity to allow native fish movement and to access new habitats • Encourage female platypus to select nesting burrows higher up the bank to reduce the risk of a high flow later in the year flooding burrows when juveniles are present	
Summer/autumn low flow (40-50 ML/day[3] at the Campaspe Siphon during December to May)	• Maintain slackwater habitats for zooplankton and nursery habitats for native fish • Maintain the water depth and prevent stratification in deep pools in summer to maintain habitat for native fish and platypus • Inundate a variety of habitats to increase the growth of biofilms and support waterbug productivity • Allow platypus to safely move between pools while foraging, and ensure there is adequate food for lactating females • Reducing flow to 20 ML/day in reaches 2 and 3 in autumn will expose mudflats and encourage the recruitment of some fringing vegetation	
Summer/autumn freshes (three freshes of 100-200 ML/day for one to three days during December to May) 	• Increase longitudinal connectivity to allow native fish to access new habitats • Wet submerged wood and flush fine silt and old biofilms to promote new biofilm growth and increase waterbug productivity for native fish and platypus • Facilitate the downstream dispersal of juvenile platypus in April/May to colonise other habitat areas	

Potential environmental watering action	Expected watering effects	Environmental objectives
Year-round fresh (trigger-based, 5-200 ML/day as required) *Triggers:* • *the oxygen level is below 5 mg/L* • *the air temperature is above 28°* • *there are high water temperatures and/or low river flow*	• Destratify pools and improve water quality (increase oxygen levels) along the river in reach 4, ensuring there is adequate oxygen to support aquatic animals (such as native fish and platypus)	

1 A greater-magnitude flow rate will wet a larger perimeter of the riverbank, supporting increased littoral vegetation.
2 A second winter/spring fresh may be delivered under average or wet climate scenarios to further enhance the river conditions if required.
3 Reach 4 flow will target 40-50 ML/day. However, a reduction in flow to 20-30 ML/day at reaches 2 and 3 may be considered in autumn to expose the river's mudflats and promote native vegetation recruitment. To achieve these two flow rate targets, water for the environment from the Goulburn flows will need to be delivered to reach 4 at the Campaspe Siphon.

Scenario planning

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

Planned watering actions for the Campaspe River focus on meeting low-flow targets throughout the year and delivering a mix of small and medium-sized freshes. Low-flow actions will likely be delivered at the lower end of the target magnitude range under dry and drought scenarios to conserve water, and the number of freshes delivered will also likely vary between scenarios.

Under a drought scenario, there is unlikely to be enough available supply to deliver summer/autumn freshes to boost ecosystem productivity and allow fish and platypus to disperse. There is also likely to be less need for these flows under drier scenarios because platypus and fish may not breed. Available water will instead be used to deliver small to medium-sized freshes when needed, to maintain pool habitat and improve water quality to prevent significant losses of existing plants and animals. North Central CMA will monitor water levels and water quality throughout the year to inform the timing of these trigger-based freshes.

Under average and wet climate scenarios, there will be more available supply. This will allow more freshes to be delivered to help increase the size and condition of platypus, native fish and native plant populations. A second winter/spring fresh will only be delivered if it can be timed to not interfere with potential Murray cod breeding.

Flow may be lowered to about 20 ML per day in reaches 2 and 3 in autumn under all scenarios to encourage recruitment of fringing plants on exposed mudflats. This action is a joint initiative between North Centra CMA and vegetation ecologists working on VEFMAP, and it will be supported by dedicated monitoring if it proceeds. Lowering flow in reach 4 may pose a risk to water quality, so the watering trial will only proceed if sufficient water can be delivered from the Western Waranga Channel to supplement flow downstream of the Campaspe Siphon.

The carryover target for 2023-24 is based on the volume required to deliver priority summer/autumn low flow during 2023-24 if there is a return to dry or drought conditions. No carryover targets are set for the average/wet scenario as early-season allocations are likely to be sufficient to meet summer/autumn low flow environmental flow demands.

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

Planning scenario	Drought	Dry	Average/Wet
Expected river conditions	• Little to no natural flow from tributaries and local run-off • Low passing flow • Operational water deliveries	• Some natural flow from tributaries and local run-off • Increased passing flow • Operational water deliveries	• Moderate to high natural flow from tributaries and local run-off • Increased passing flow • No expected spills from storage, except under extremely wet conditions
Expected availability of water for the environment	• 19,500 ML	• 25,200 ML	• 30,400 ML
Campaspe River (targeting reach 4)			
Potential environmental watering – tier 1 (high priorities)	**Tier 1a (can be achieved with predicted supply)**		
	• Winter/spring low flow (at lower magnitude) • Winter/spring fresh (one fresh) • Summer/autumn low flow[1] • Year-round fresh (if required)	• Winter/spring low flow • Winter/spring fresh (one fresh) • Summer/autumn low flow[1] • Summer/autumn freshes (three freshes) • Year-round fresh (if required)	• Winter/spring low flow • Winter/spring fresh (one to two freshes[2]) • Summer/autumn low flow[1] • Summer/autumn freshes (three freshes) • Year-round fresh (if required)
	Tier 1b (supply deficit)		
	• Summer/autumn freshes (three freshes)	• N/A	• N/A
Potential environmental watering – tier 2 (additional priorities)	• N/A		
Possible volume of water for the environment required to achieve objectives	• 19,000 ML (tier 1a) • 900 ML (tier 1a Goulburn) • 2,100 ML (tier 1b)	• 24,500 ML (tier 1a) • 1,200 ML (tier 1a Goulburn)	• 26,400 ML (tier 1a) • 1,200 ML (tier 1a Goulburn)
Priority carryover requirements for 2023-24	• 7,500 ML[3]	• 6,000 ML[3]	• N/A

1 This potential watering action may have a period of a lower flow rate in reaches 2 and 3 (20 ML/day) while maintaining the 40-50 ML/day flow in reach 4. To achieve this outcome, water for the environment from the Goulburn will need to be delivered to reach 4 at the Campaspe Siphon.
2 A second winter/spring fresh may be delivered under average or wet climate scenarios to further improve streamside vegetation by wetting riverbanks, support fish movement and clear accumulated leaf litter to reduce the risk of blackwater events during summer high flow.
3 These carryover targets may be achieved by trading water from other systems, and they have not been included in the determination of potential watering actions in this climate scenario.

5.6.2 Coliban River

System overview

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

Flow in the Coliban River below Malmsbury Reservoir is regulated by the operation of the Malmsbury, Lauriston and Upper Coliban reservoirs. An important distinction between the Coliban River and other regulated Victorian systems is the lack of irrigation demand that may be met by managed releases downstream of system storages. Flow in the river is influenced by the passing-flow entitlement, which depends on catchment inflows and major flood events in the catchment.

The VEWH does not have any environmental entitlements in the Coliban system, but passing flows can be managed — for example, they can be accumulated and released when most needed — to help mitigate some risks associated with critically low summer/autumn flow, including low oxygen levels in the river between Malmsbury Reservoir and Lake Eppalock. A small volume of Commonwealth water for the environment is held in the system, but the high cost of delivery means there is no plan to use it in 2022-23.

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Environmental values

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

Environmental watering objectives in the Coliban River

Icon	Environmental objectives in the Coliban River
	Increase the abundance and diversity of small-bodied native fish Facilitate recolonisation by native fish species (including river blackfish) that have been presumed lost
	Maintain the platypus population
	Increase the cover and diversity of aquatic plants Increase the cover and diversity of fringing vegetation while limiting encroachment into the middle of the channel Maintain streamside woody vegetation and facilitate recruitment
	Maintain an adequate diversity and biomass of waterbugs to break down dead organic matter and supply the river's food chain
	Maintain water quality to support aquatic life and ecological processes

Traditional Owner cultural values and uses

In planning for environmental flows in the Coliban River, Dja Dja Wurrung Clans Aboriginal Corporation (trading as DJAARA) Kapa Gatjin (water advisory) Group and North Central CMA have considered how environmental water management assists with the preservation of historical and contemporary cultural values including promoting a sense of place and spiritual connection.

The *Dhelkunya Dja (Healing Country) Country Plan 2014-2034* describes their aspirations around the management of rivers and waterways and articulates Djaara's (Dja Dja Wurrung peoples') support for the reinstatement of environmental flows as an overall objective for the management of water on Country.

The Kapa Gatjin and North Central CMA have been working together to identify opportunities and sites where water for the environment can support the Djaara's aspirations for the Coliban River and play a greater role in the management and administering of environmental water, with an aim of future ownership and management of environmental water.

Social, recreational and economic values and uses

In planning the potential watering actions in Table 5.6.3, North Central CMA considered how environmental flows could support values and uses, including:

- water-based recreation (such as swimming, canoeing, fishing and water sports)
- riverside recreation and amenity (such as socialising, relaxing, birdwatching, bushwalking, camping and cycling)
- socio-economic benefits (such as tourism to Malmsbury, diversions for domestic and stock uses, benefits to the local and regional economies from recreational activities, ecosystem services [such as carbon storage, groundwater recharge and water-quality regulation], lower salinity costs and blackwater and blue-green algae risks for landholders and contributions to community enjoyment, health and recuperation).

Recent conditions

Rainfall in the Coliban River catchment during 2021-22 was close to the long-term average. Accumulated passing flows that made up the holdings of water for the environment were lost when Malmsbury Reservoir spilled in late July 2021. However, unregulated and natural flows following this spill provided the required winter/spring low flow and six freshes between July and January. The largest event peaked at 1,493 ML per day at Lyal in September 2021, and it was the largest flow in the river since the 2016 floods.

Deliveries of water for the environment for the Coliban system were managed in line with an average climate scenario throughout 2021-22. All planned watering actions for the Coliban River were fully or partially achieved with passing flow, natural inflow and/or the managed release of accumulated passing flow. Passing flow provided continuous flow between Malmsbury Reservoir and Lake Eppalock, and 2021-22 was the first year since 2011-12 that the Coliban River had not had a cease-to-flow event. Some accumulated passing flow was used to deliver a fresh in April 2022 to support the dispersal of juvenile platypus.

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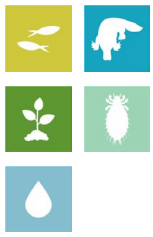
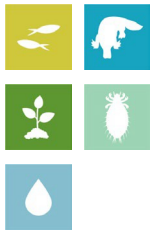
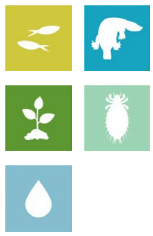
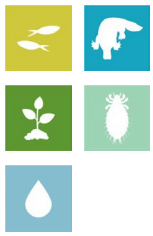
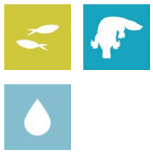
Scope of environmental watering

Table 5.6.3 describes the potential environmental watering actions in 2022-23, their expected watering effects (that is, the intended physical or biological effects of the watering action) and the longer-term environmental objectives they support. Each environmental objective relies on one or more potential environmental watering actions and their associated physical or biological effects.

Table 5.6.3 Potential environmental watering actions, expected watering effects and associated environmental objectives for the Coliban River

Potential environmental watering action	Expected watering effects	Environmental objectives
Coliban River (targeting reach 1)		
Winter/spring low flow (2-10 ML/day during June to November)	• Maintain a connected river that allows small-bodied native fish and platypus to disperse throughout it • Increase wet areas for native aquatic and streamside plants while limiting terrestrial species encroaching into the river channel • Mix water in pools to prevent stagnation and a decline in water quality • Increase the wetted area for habitat for waterbugs	
Winter/spring fresh (one fresh of up to 160 ML/day for three to five days during June to November)	• Maintain up to 65 cm water depth between pools, so native fish can disperse throughout the river and colonise sites • Encourage female platypus to select a nesting burrow higher up the bank to reduce the risk of a greater flow later in the year flooding the burrow when juveniles are present • Increase the wetted river perimeter for fringing and edge vegetation • Increase the wetted river perimeter to increase habitat for waterbugs • Flush organic matter to reduce the risk of declining water quality in summer	
Summer/autumn low flow (2-10 ML/day during December to May)	• Maintain up to 6 cm water depth between pools for native fish movement, and maintain river pool depth • Wet the channel to maintain in-stream aquatic and fringing vegetation • Maintain aquatic habitat that supports waterbugs, native fish and platypus • Maintain water quality, including oxygen levels	
Summer/autumn freshes (two freshes of 25-160 ML/day for three to five days during December to May)	• Increase the water depth through riffle-run habitats to 8-20 cm for a 25-50 ML/day event to maintain water quality and habitat for waterbugs • Increase the water depth through riffle-run habitats to 45-60 cm for a 160 ML/day event to: - facilitate the movement of fish and platypus - clean sediment and biofilms from river substrates - wet the benches and low banks to promote the growth and recruitment of fringing vegetation	
Pulsed summer/autumn low flow (5-15 ML/day for up to 14 days during December to May, trigger-based) *Triggers:* • *the oxygen level is below 5 mg/L* • *the air temperature is above 28°* • *there are low or cease-to-flow river conditions*	• Improve water quality, including oxygen levels • Maintain refuge habitat for aquatic animals, including fish and platypus	

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Scenario planning

Table 5.6.4 outlines potential environmental watering and expected water use under a range of planning scenarios.

The potential environmental flows required for the Coliban River include low flow and freshes under all climate scenarios, but the magnitude of particular flows and the numbers and durations of freshes that can be delivered will vary between scenarios, based on available supply and other flows in the system. Where supply is limited, low flow will be delivered at the lower end of the recommended magnitude to maintain some connecting flow for a longer period. Freshes will be delivered where possible to facilitate the dispersal of platypus and fish and clean biofilms from in-stream surfaces.

The highest-priority watering action in the Coliban River under all climate scenarios is the summer/autumn low flow to maintain sufficient habitat for native fish, platypus and waterbugs. Natural baseflow and tributary inputs help to maintain some flow through the Coliban River during winter and spring each year, but long sections of the river contract to a series of pools or completely dry during late summer and autumn, especially in dry years. Releases of water for the environment in summer and autumn help to maintain water quality (especially when oxygen levels are low) and maintain the depth of pools in the upper reaches to help sustain populations of native fish and platypus. Providing Malmsbury Reservoir does not spill over winter/spring, passing flows that were banked but not used in 2021-22 will be carried over and used to help maintain a continuous low flow under all climate scenarios in 2022-23. If a continuous flow cannot be maintained, shorter, pulsed flows may be delivered to maintain refuge habitats as required. These trigger-based pulses will most likely be needed under a dry scenario but may also be needed under wetter scenarios if there is insufficient supply to deliver continuous low flow in late summer or early autumn. Where possible, summer and autumn freshes will be delivered to facilitate fish and platypus movement and support fringing vegetation. These freshes will aim to be delivered in March or April to support juvenile platypus dispersal and reduce predation.

Accumulated passing flows can be carried over for use in the next year, but it will be forfeited if Malmsbury Reservoir spills. A carryover target of 720 ML has been set for all climate scenarios to ensure enough supply for high-priority summer and autumn low flows in 2023-24. This target will be revised throughout the year based on climatic forecasts, the risk of spill and the extent to which priority actions for 2022-23 have been met. For example, delivering at least one summer/autumn fresh in 2022-23 will be a higher priority than achieving the full 720 ML carryover target.

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

Planning scenario	Drought	Dry	Average/Wet
Expected river conditions	• Little to no natural flow	• Some natural flow	• Extended periods of natural flow, including some high-flow events and reservoir spills
Expected availability of water for the environment[1]	• 1,600 ML	• 2,000 ML	• 2,800 ML
Coliban River (targeting reach 1)			
Potential environmental watering – tier 1 (high priorities)	**Tier 1a (can be achieved with predicted supply)**		
	• Winter/spring low flow (lower magnitude in the range) • Summer/autumn low flow (lower magnitude in the range) • Pulsed summer/autumn low flow (trigger-based)	• Winter/spring low flow • Summer/autumn low flow • Summer/autumn fresh (one fresh, lower magnitude) • Pulsed summer/autumn low flow (trigger-based)	• Winter/spring low flow • Summer/autumn low flow • Summer/autumn fresh(es) (one to two freshes, lower magnitude) • Pulsed summer/autumn low flow (trigger-based)
	Tier 1b (supply deficit)		
	• Summer/autumn low flow (higher magnitude) • Summer/autumn fresh (one to two freshes)	• Winter/spring fresh (one fresh) • Summer/autumn fresh (one additional fresh, increased magnitude)	• Winter/spring fresh (one fresh) • Summer/autumn fresh (one to two freshes at higher in magnitude)

Planning scenario	Drought	Dry	Average/Wet
Potential environmental watering – tier 2 (additional priorities)	• N/A		
Possible volume of water for the environment required to achieve objectives	• 1,460 ML (tier 1a) • 920 ML (tier 1b)	• 1,870 ML (tier 1a) • 1,900 ML (tier 1b)	• 2,280 ML (tier 1a) • 2,500 ML (tier 1b)
Priority carryover requirements for 2023-24	• 720 ML		

1 As there is no formal environmental entitlement in the Coliban River, these are estimated volumes of passing flows that may be accumulated for a managed environmental flow.

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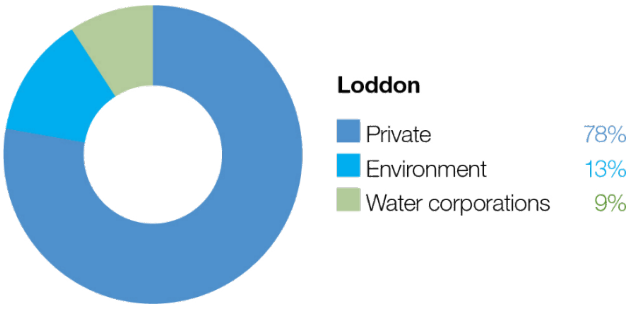
5.7 Loddon system

Waterway manager – North Central Catchment Management Authority

Storage manager – Goulburn-Murray Water

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

Proportions of water entitlements in the Loddon basin held by private users, water corporations and environmental water holders on 30 June 2020



The Loddon system includes the Loddon River system (including Tullaroop, Serpentine and Pyramid creeks), the Boort Wetlands and Birchs Creek subsystems.

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

System overview

The Loddon River flows from the Great Dividing Range in the south to the Murray River in the north. Tullaroop Creek is the main tributary in the upper Loddon River system (Figure 5.7.1). The middle section of the Loddon River is characterised by many distributary streams and anabranches that carry water away from the river onto the floodplain. The lower Loddon River is joined by Pyramid Creek at Kerang, at which point the Loddon becomes part of the Murray River floodplain.

The two main storages on the Loddon River are Cairn Curran Reservoir and Tullaroop Reservoir. Laanecoorie Reservoir is a smaller storage that is used to regulate water released from the larger upstream storages. Flow in the Loddon River downstream of Laanecoorie Reservoir is regulated by the operation of the Bridgewater, Serpentine, Loddon and Kerang weirs.

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

The highly regulated nature of the Loddon system provides both challenges and opportunities for effective management of water for the environment. The ability to manipulate the timing of releases at multiple locations can help achieve environmental outcomes at discrete locations. However, coordinating environmental flows and consumptive flows is difficult through the irrigation season, especially when irrigation demand is high or flow in the river is highly variable. These issues can constrain the timing and delivery of water for the environment or lead to greater-than-recommended flows above Loddon Weir. The structures used for managing irrigation water form barriers in the waterway, restrict flow reliability and create barriers to aquatic animal movement throughout the river, which make it harder to achieve good outcomes for native fish and possibly platypus.

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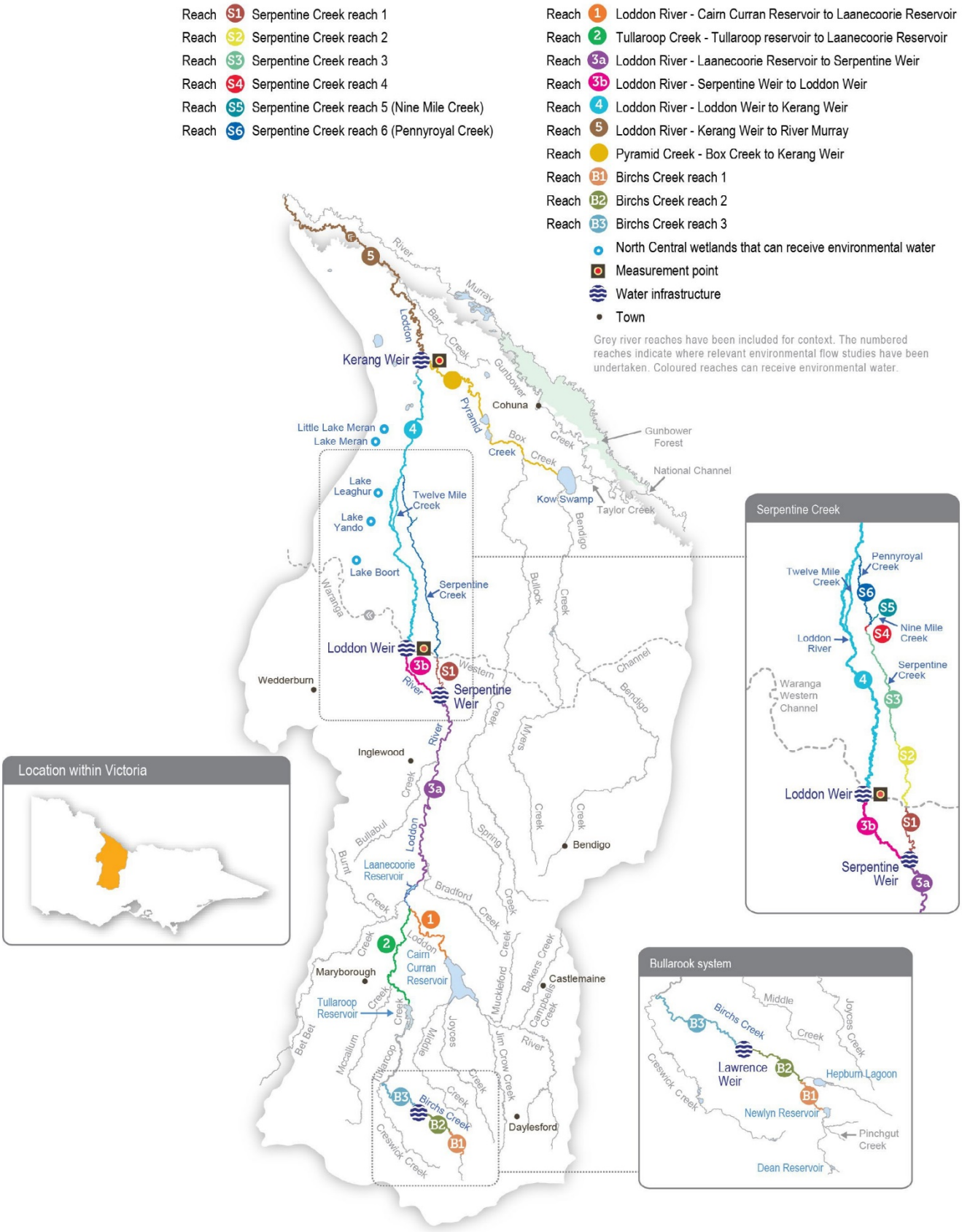
Figure 5.7.1 The Loddon system



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Environmental values

The Loddon River system supports platypus, rakali (water rats) and several species of native fish (such as Murray cod, golden perch, silver perch, river blackfish and Murray-Darling rainbowfish). Streamside vegetation varies in condition depending on the recent water regime, the extent of clearing and historic and current land management practices. The areas that remain relatively intact support a variety of woodland birds and other native animals. Important plant species across the system include cane grass, tangled lignum, black box and river red gum.

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

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

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

Environmental watering objectives in the Loddon River system

Icon	Environmental objectives in the Loddon River system
	Increase populations of small and large-bodied native fish Provide habitat for fish to feed and breed and opportunities for movement between habitats
	Enhance the channel form and features, including deep pools and benches Maintain the condition of suitable substrate to maintain ecosystem processes Engage floodrunners, distributary channels, anabranches and backwaters
	Increase the population and recruitment of resident platypus Maintain a stable rakali (water rat) population in the long term
	Maintain productive and dynamic food webs Maintain/increase the diversity and abundance of biofilms
	Maintain the condition of streamside and floodplain vegetation Maintain and increase the extent of in-stream vegetation
	Maintain the diversity and increase the abundance of waterbugs and waterbug functional feeding groups
	Maintain water quality to support aquatic animals and minimise the occurrence of blackwater events

Traditional Owner cultural values and uses

The Barapa Barapa and Wamba Wemba are the Traditional Owners in the northern part of the Loddon catchment, and the Djaara (Dja Dja Wurrung People) are the Traditional Owners in the southern part of the catchment. Artefacts of cultural practices are present throughout the Loddon and Pyramid system and its floodplain.

In planning for environmental flows in the Loddon River system, Djaara, Barapa Barapa and Wamba Wemba and North Central CMA have considered how environmental flows in the Loddon system can be managed to support their respective values, priorities and uses.

In the southern part of the catchment, Dja Dja Wurrung Clans Aboriginal Corporation (trading as DJAARA) Kapa Gatjin (water advisory) Group and North Central CMA have been working together to identify opportunities and sites where water for the environment can support Djaara aspirations for the Loddon River. A key aspiration is for Djaara to play a greater role in the management and administering of environmental water, with an aim of future ownership and management of environmental water.

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Recently DJAARA conducted a Cultural Values Assessment (CVA) – similar to an Aboriginal Waterways Assessment (AWA) – at two sites along the Loddon River. The assessments included detailed visual inspections, questionnaires and data analysis. On Country DJAARA participated in two-way learning with North Central CMA staff. Discussion points included cultural heritage, effects of river regulation, and alignment of watering and cultural objectives. This is the beginning of a longer journey to collaborate on realising joint aspirations for the Loddon River.

In early 2022, Barapa Barapa and Wamba Wemba Traditional Owners joined North Central CMA staff on Country to reflect upon environmental watering in the Loddon River system in 2021-22 and to discuss aspirations for 2022-23. Barapa Barapa and Wamba Wemba Traditional Owners emphasised the importance of water for the environment in supporting fish populations (such as Murray cod and golden perch) in the Loddon River system, particularly over summer.

Barapa Barapa and Wamba Wemba Traditional Owners discussed a long-term vision to create a golden perch nursery at Kow (Ghow) Swamp and supported the North Central CMA re-snagging of Pyramid Creek. Traditional Owners also expressed the need for improved access to Pyramid Creek, and the fact that private land tenure often creates impediments to floodplain watering and Traditional Owner restoration efforts on Country.

Barapa Barapa Traditional Owners have communicated their cultural objectives for the Loddon River and other waterways in the Barapa Barapa Healthy Country Plan. Objectives that relate to the Loddon River system include:

- all wetlands surrounding the Murray River, Gunbower Forest, Loddon River and associated lakes have good plant life and healthy native fish (cod and yellow belly), mussels and turtle populations by 2033
- by 2033, the Murray, Gunbower, Loddon and associated lakes will have enough water. Water quality is improving and water is clear for most of the year in good years
- Barapa people are actively involved in water management
- reduce the number of major fish and plant deaths from toxic blackwater events to improve water quality.

Social, recreational and economic values and uses

In planning the potential watering actions in Table 5.7.1, North Central CMA considered how environmental flows could support values and uses, including:

- water-based recreation (such as fishing, powered and non-powered boating, water skiing and water sports)
- riverside recreation and amenity (such as birdwatching, bushwalking, camping and cycling)
- community events and tourism (such as water skiing competitions at Bridgewater and associated visitation)
- socio-economic benefits (such as diverters for domestic and stock uses, local and regional economic benefits from increased visitation and ecosystem services, including carbon storage, groundwater recharge and nutrient recycling).

If the timing or management of planned environmental flows may be modified to align with a community benefit, this is acknowledged in Table 5.7.1 with the following icon.

Watering planned to support water sports activities (e.g. water skiing)

If possible, North Central CMA will work with Goulburn-Murray Water to manage the delivery of low flow rates and the timing of freshes over summer/autumn to support optimum conditions for annual water skiing competitions at Bridgewater weir pool, where possible.

Recent conditions

Rainfall across the Loddon system during 2021-22 was close to the long-term average, while temperatures were warmer than average. Two unregulated high-flow events occurred in the Loddon River in August and November; the largest event peaked at 961 ML per day at Loddon Weir on 5 November. High-reliability water share allocations in the Loddon system opened at 33 percent at the start of July and reached 100 percent by early October. No low-reliability water share allocation was issued in 2021-22. The VEWH also traded 5 GL into the Loddon system from its Goulburn entitlements to support planned watering actions in 2021-22.

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Deliveries of water for the environment for the Loddon system were managed in line with an average climate scenario during 2021-22. Most planned watering actions for the Loddon River, Serpentine Creek and Pyramid Creek were achieved through the use of environmental flow, passing flow, releases for consumptive use and some unregulated flow.

The winter/spring high flow in reach 4 of the Loddon River and Pyramid Creek was coordinated in October 2021 to deliver a high flow at Kerang Weir that aimed to cue native fish to move into the system from the Murray River. The flow was delivered at a slightly lower magnitude than in previous years — peak flow at Kerang Weir was 638 ML per day on 17 October — to avoid flooding private land. The effectiveness of the lower flow rate is yet to be confirmed by monitoring.

Heavy rainfall in January 2022 delivered a natural fresh in the lower Loddon River that washed a lot of organic matter into the river and caused low oxygen levels during a subsequent hot spell. North Central CMA delivered one of three planned summer/autumn freshes to increase oxygen levels, but it was not effective, and a larger fresh — 200 ML per day — was delivered under the emergency watering provision to prevent fish deaths. Water for the environment was also used to deliver a summer fresh in Serpentine Creek in late January to alleviate water quality issues.

Flow in Pyramid Creek was reduced in May and June 2022 to allow water levels to draw down in Kow (Ghow) Swamp. The low flow remained within the minimum recommended range, and it was not considered harmful to native fish or other environmental values in the creek.

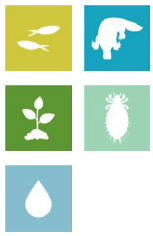
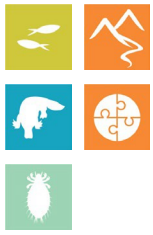
Two planned watering actions were not delivered in 2021-22. The first was a combined autumn high flow in the Loddon River and Pyramid Creek, which aimed to trigger the upstream movement of native fish from the Murray River and facilitate the dispersal of juvenile platypus. This is the second consecutive year that capacity constraints in Pyramid Creek have prevented delivery of an autumn high flow, and delivering it in 2022-23 will be a high priority to help achieve environmental objectives for native fish and platypus. The second planned watering action not achieved in 2021-22 was a winter/spring fresh in Serpentine Creek. It was not delivered to avoid potential flooding of private land at the end of the system. The flood risk applies to any increased flow in Serpentine Creek that cannot be redirected back into the irrigation channel system. The North Central CMA, storage manager and the VEWH have partly resolved the issue to allow summer/autumn freshes to be delivered in Serpentine Creek, and we will continue to explore options that will allow larger environmental flows to be safely delivered in future.

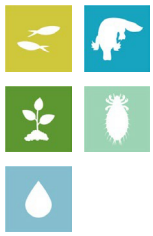
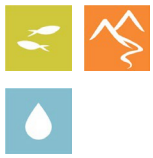
Scope of environmental watering

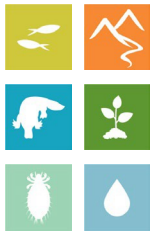
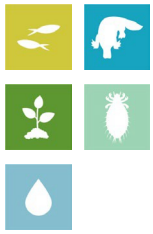
Table 5.7.1 describes the potential environmental watering actions in 2022-23, their expected watering effects (that is, the intended physical or biological effects of the watering action) and the longer-term environmental objective(s) they support. Each environmental objective relies on one or more potential environmental watering actions and their associated physical or biological effects.

Table 5.7.1 Potential environmental watering actions, expected watering effects and associated environmental objectives for the Loddon River system

Potential environmental watering action	Expected watering effects	Environmental objectives
Loddon River (targeting reach 4)		
Winter/spring low flow (25-100 ML/day during June to November)	• At 25-50 ML/day, low flows will provide a minimum level of continuous flow through the reach and maintain water quality[1] • At 100 ML/day: - increase the water depth for fish, platypus and rakali (water rat) dispersal (especially for male juvenile platypus) to colonise new breeding territory in winter and provide foraging habitat - prevent silt and fine sediment from settling on submerged wood and other hard surfaces - inundate a variety of habitats to increase the growth of biofilms and support waterbug productivity - water the native fringing bank vegetation to support seed germination and growth and prevent the encroachment of exotic terrestrial plants in the river channel	
Winter/spring low flow trial (100-200 ML/day for one to 10 days during June to November, if triggered by an unregulated flow event)	• Increased longitudinal connectivity by drowning out fish barriers to allow fish to access new habitats • Inform future works to modify or remove fish barriers	

Potential environmental watering action	Expected watering effects	Environmental objectives
Winter/spring high flow (one high flow of 400-450 ML/day for six to 10 days during August to November)	• Provide sufficient velocity to scour accumulated sediment from pools and scour biofilms, promoting the growth of new biofilms and increasing waterbug productivity • Flush accumulated organic matter from the bank and benches to increase productivity and reduce the risk of a hypoxic blackwater event in summer • Wet the banks to promote the recruitment and growth of streamside and emergent vegetation • Stimulate native fish movement and breeding	
Summer/autumn low flow (25-50 ML/day during December to May)[2] 	• At 25 ML/day, low flows will provide a minimum level of continuous flow through the reach • At 50 ML/day: - maintain an adequate depth in pools for aquatic plants and to provide habitat for waterbugs, fish and rakali (water rats) - provide continuous flow through the reach to maintain water quality - wet the banks and shallow riffles to support the growth of in-stream and fringing non-woody vegetation	
Summer/autumn low flow trial (50-100 ML/day for one to two months during January to February, if triggered by hot conditions)	• Provide continuous flow through the reach to maintain water quality and potentially mitigate against a hypoxic blackwater event • Prevent emigration of native fish species due to low water quality	
Summer/autumn freshes (three freshes of 100 ML/day for three days during December to May) 	• Increase the water level to promote seed germination and the growth of fringing emergent macrophytes • Increase connectivity between deep pools to promote the local movement of fish and prompt the dispersal of juvenile platypus in autumn • Generate sufficient force to flush fine sediment and old biofilms from submerged wood and other hard surfaces, promoting the growth of new biofilms and increasing waterbug productivity • Freshen water quality and reoxygenate pools	
Autumn high flow (one high flow of 400 ML/day for six days[3] during March to May)	• Trigger and facilitate the upstream movement of golden perch, silver perch and Murray cod older than one year • Facilitate the dispersal of juvenile platypus • Generate sufficient force to flush fine sediment and old biofilms from submerged wood and other hard surfaces, promoting the growth of new biofilms and increasing waterbug productivity	
Year-round fresh (trigger-based, 50-200 ML/day as required) *Triggers:* • *the oxygen level is below 5 mg/L* • *the air temperature is above 28°* • *there are low or cease-to-flow river conditions* • *there are high water temperatures and/or low river flow*	• Destratify pools and improve water quality (increase oxygen levels) along the river in reach 4, ensuring there is adequate oxygen to support aquatic animals (such as native fish and platypus)	

Potential environmental watering action	Expected watering effects	Environmental objectives
Pyramid Creek and Loddon River (targeting reach 5)		
Year-round low flow (90-300 ML/day at Box Creek regulator)	• At 90 ML/day, low flow will maintain connectivity between pools and provide habitat for aquatic animals At 200 ML/day: • increase longitudinal connectivity to allow native fish and platypus to access new habitats • improve water quality by reducing salinity levels • increase the wetted area to maintain and promote the growth of fringing emergent (non-woody) vegetation along the lower banks of the channel At 300 ML/day: • facilitate greater movement for large-bodied native fish • wet a larger perimeter of the riverbank to enhance the growth of fringing emergent (non-woody) vegetation along the lower banks of the channel • increase hydrodynamic diversity and improve the quality of flowing habitats	
Winter/spring high flow (one high flow of 650 ML/day at Kerang Weir for 10 days)[4]	• Trigger the migration, spawning and recruitment of native fish species, including Murray cod • Maintain connectivity between habitats and improve water quality • Provide sufficient energy to flush accumulated sediment from pools and substrates	
Autumn high flow (one high flow of 650 ML/day at Kerang Weir for six days[3] during March to April)[4]	• Trigger and facilitate the upstream movement of golden perch, silver perch and Murray cod older than one year • Maintain connectivity between habitats and improve water quality • Facilitate platypus dispersal • Provide sufficient energy to flush accumulated sediment from pools and substrates	
Serpentine Creek (targeting reach 1)[5]		
Winter/spring low flow (10-30 ML/day[6] during June to November)	• At 10 ML/day, low flow will maintain connectivity between habitats • At 20-30 ML/day: - maintain habitat for native fish and facilitate movement for aquatic animals - wet exposed roots, woody debris, emergent vegetation and leaf packs to provide habitat for aquatic animals - maintain water quality by preventing stagnation - provide flow variability to maintain the diversity of fringing vegetation - provide a sufficient depth of water and variability of flow to maintain microbial biofilms	

Potential environmental watering action	Expected watering effects	Environmental objectives
Winter/spring fresh (one fresh of 40-120 ML/day[6] for two days during August to November)	• Provide connectivity for fish and waterbugs to access different habitat areas, supporting a diversity of functional feeding groups • Transport organic matter that has accumulated in the channel, to increase the breakdown of organic matter in winter/spring • Wet the banks to promote the recruitment and growth of streamside and emergent vegetation • At 120 ML/day: - maintain the channel form and scour pools - encourage female platypus to select nesting burrows higher up the bank to reduce the risk of greater flow later in the year flooding burrows when juveniles are present - flush accumulated leaf litter from the banks and low benches to reduce the risk of blackwater events during summer	
Summer/autumn low flow (10-20 ML/day[6] during December to May)	• Provide connectivity between pools to allow the dispersal of small- to medium-bodied native fish • Wet exposed roots, leaf packs and woody debris to provide habitat for aquatic animals • Provide sufficient flow to maintain water quality by oxygenating pools • Maintain foraging habitat for platypus • Maintain the wetted area to support in-stream aquatic vegetation (such as water ribbons, eel weed and milfoil)	
Summer/autumn freshes (three freshes of 40 ML/day[6] for two days during December to May)	• Maintain the channel form by inundating benches • Generate sufficient force to flush fine sediment and old biofilms from submerged wood and other hard surfaces, promoting the growth of new biofilms, increasing waterbug productivity and replenishing the food supply for aquatic animals • Increase connectivity between pools to promote the local movement of fish and prompt the dispersal of juvenile platypus in autumn • Transport organic matter that has accumulated in the channel to provide carbon and nutrients downstream • Provide flow variability to maintain the diversity of fringing vegetation (such as emergent macrophytes) • Freshen water quality by diluting salt and reoxygenate pools	

1 Winter/spring low flow of 50 ML per day is below the passing flow magnitude and will result in the VEWH banking passing flows savings for use in other potential watering actions.
2 Under all scenarios, a 100 ML/day summer low flow rate may be trialled in January and February to mitigate hypoxic blackwater and prevent the emigration of native fish species.
3 The peak magnitude of this event is planned to be delivered for six days, but there is an extended, 14-day ramp-down period.
4 Winter/spring and autumn freshes are planned to occur at the same time in the Loddon River and Pyramid Creek, with the peak timed to meet at Kerang Weir. 650 ML/day is the total combined target at Kerang Weir.
5 Flow in Serpentine Creek may be allowed to either return to the Loddon River or continue down Pennyroyal and Bannacher creeks or Nine Mile Creek with the agreement of landholders.
6 Flow delivered from Serpentine Weir may be restricted to manage end-of-system outfalls to avoid third-party impacts until an alternate solution is determined.

Scenario planning

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

Loddon River

In the Loddon River, delivery of three summer/autumn freshes and continuous, year-round low flow are high priorities under all climate scenarios to maintain habitat for native fish, platypus and native vegetation and prevent poor water quality. Flow will likely be delivered at the lower end of the recommended range under drought conditions to conserve supply. Lower magnitude flow will aim to prevent critical harm to aquatic plants and animals rather than improve their condition. Low-oxygen incidents in recent years have highlighted the need for a fresh that can be delivered at any time to respond to poor water quality. This new watering action may be delivered up to a magnitude of 200 ML per day, based on the flow rate needed to improve water quality in 2017 and 2022, and it is considered a high priority under all climate scenarios.

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The prescribed passing flow in the Loddon River between May and October is 77 ML per day. Under the drought climate scenario, the passing flow may be reduced to 25 ML per day (in consultation with Goulburn-Murray Water) to accrue additional water savings that can be used to supplement flow in summer and autumn, when there are higher risks of poor water quality, and to prevent cease-to-flow events in reaches that do not carry consumptive water. The forecast high water availability will potentially allow summer/autumn freshes to be delivered at 100 ML per day under all climate scenarios in 2022-23. Under a dry climate scenario, the winter/spring low flow will likely be delivered at the standard passing flow rate of 77 ML per day, and the summer/autumn low flow will be delivered at 40 ML per day. If additional water becomes available or an average or wet scenario eventuates, water for the environment may be used to increase winter/spring low flow to 100 ML per day and summer/autumn low flow to 50 ML per day to improve the condition of vegetation higher up the bank, improve water quality and increase the abundance and improve the condition of fish and platypus populations.

Fish ecologists have recommended trialling different flow rates to improve fish outcomes in the Loddon River if sufficient water is available. The first trial is to increase summer/autumn low flow to 100 ML per day during January and February if hot conditions are forecast to reduce the risk of fish emigration and mitigate water quality issues. The second trial involves increasing the winter/spring low flow to 200 ML per day after an unregulated event to increase fish passage past low-level barriers. The first trial may occur under any scenario if there is an available supply, but the second trial will only be considered if there are large natural events; it is, therefore, more likely under a wet climate scenario. There will need to be appropriate monitoring as part of either trial.

Pyramid Creek

Pyramid Creek is regionally significant for native fish. Fish populations within Pyramid Creek have increased since the Millennium Drought, and the removal of fish barriers means it is now an important dispersal corridor for fish moving between the Murray River, Kow (Ghow) Swamp and Gunbower Creek. Maintaining adequate low flow to allow fish to remain in Pyramid Creek all year (including during the non-irrigation season) and delivering high flow to cue and facilitate fish movement at key times of the year are high priorities under all climate scenarios.

Modelling conducted by the Arthur Rylah Institute indicates that maintaining a low flow of at least 200 ML per day throughout the year in Pyramid Creek is optimal for resident fish populations. Maintenance and fishway construction works planned for the 2023 irrigation shut-down period may affect water deliveries to Pyramid Creek and make it difficult to maintain a flow of at least 200 ML per day. North Central CMA and the storage manager will aim to maintain flow within a range of 90-300 ML per day in Pyramid Creek during this period if construction works proceed.

The winter/spring high flow in Pyramid Creek has a target flow rate of 650 ML per day at Kerang Weir, which requires coordinated releases in Pyramid Creek and reach 4 of the Loddon River. The ideal duration of this event is 10 days, but it may be reduced to six days under a drought or dry climate scenario to conserve water. The reduced duration should still be sufficient to allow many fish to move through the system. A similar-sized event in autumn is recommended for average and wet climate scenarios, when large numbers of juvenile fish are likely to be trying to migrate from the Murray River into the Loddon system. It may also be delivered under drought and dry climate scenarios, if it can be delivered with the available supply or, more likely, by using operational transfers.

Serpentine Creek

In Serpentine Creek, the main priority will be to maintain low flow throughout the year to provide habitat for native fish, waterbugs, rakali (water rats) and platypus and to deliver freshes to improve water quality, allow fish and platypus movement and improve the condition of streamside vegetation. Flow will likely be delivered at the lower end of the recommended range under drought and dry climate scenarios to conserve available water.

Carryover of 4,338 ML is prioritised into 2023-24 under all scenarios. This water will help meet early-season, low-flow and winter/spring fresh demands in all waterways.

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

Planning scenario	Drought	Dry	Average	Wet
Expected river conditions	• Negligible contributions from unregulated reaches and tributaries of the Loddon River, consumptive water deliveries in the irrigation season (and none in reach 4) • Reduced passing flows in autumn/ winter are possible	• Small inflows from unregulated reaches and tributaries of the Loddon River contributing to low flow, consumptive water deliveries in the irrigation season (but not in reach 4)	• Natural flow will provide low flow and multiple freshes, most likely in winter/spring • Consumptive water deliveries in the irrigation season (but not in reach 4) • No spill is likely	• Spills from Loddon system storages will provide extended-duration high flow, and overbank flow is most likely in late winter/spring

Planning scenario	Drought	Dry	Average	Wet
Expected availability of water for the environment[1]	• 18,002-23,745 ML[2]	• 21,568 ML	• 21,568 ML	• 21,568 ML
Loddon River (targeting reach 4)				
Potential environmental watering – tier 1 (high priorities)	**Tier 1a (can be achieved with predicted supply)**			
	• Winter/spring low flow (delivered at 25-50 ML/day[3]) • Winter/spring high flow (one high flow, delivered at a lower duration)[4] • Summer/autumn low flow (delivered at 25-40 ML/day)[5] • Summer/autumn freshes (three freshes) • Year-round fresh (trigger-based)	• Winter/spring low flow (delivered at 50-77 ML/day) • Winter/spring high flow (one high flow, delivered at a lower duration) • Summer/autumn low flow (delivered at 40 ML/day) • Summer/autumn freshes (three freshes) • Year-round fresh (trigger-based)	• Winter/spring low flow (delivered at 77-100 ML/day) • Winter/spring high flow (one high flow) • Summer/autumn low flow (delivered at 50 ML/day) • Summer/autumn freshes (three freshes) • Year-round fresh (trigger-based)	• Winter/spring low flow (delivered at 77-100 ML/day) • Winter/spring high flow (one high flow) • Summer/autumn low flow (delivered at 50 ML/day) • Summer/autumn freshes (three freshes) • Autumn high flow (one high flow) • Year-round fresh (trigger-based)
	Tier 1b (supply deficit)			
	• Summer/autumn low flow (delivered at 40-50 ML/day)	• Winter/spring low flow (delivered at 77-100 ML/day) • Summer/autumn low flow (delivered at 40-50 ML/day)	• Autumn high flow (one high flow)	• N/A
Potential environmental watering – tier 2 (additional priorities)	• Winter/spring low flow delivered at 50-100 ML/day magnitude • Summer/autumn low flow trial (50-100 ML/day) • Autumn high flow (one high flow)	• Summer/autumn low flow trial (50-100 ML/day) • Autumn high flow (one high flow)	• Summer/autumn low flow trial (50-100 ML/day)	• Winter/spring low flow trial (100-200 ML/day) • Summer/autumn low flow trial (50-100 ML/day)
Possible volume of water for the environment required to achieve objectives	• 5,000-9,300 ML (tier 1a) • 600 ML (tier 1b) • 12,200 ML (tier 2)	• 9,300 ML (tier 1a) • 4,000 ML (tier 1b) • 8,800 ML (tier 2)	• 8,200 ML (tier 1a) • 3,500 ML (tier 1b) • 4,300 ML (tier 2)	• 8,400 ML (tier 1a) • 3,000 ML (tier 2)
Pyramid Creek and Loddon River (targeting reach 5)				
Potential environmental watering – tier 1 (high priorities)	**Tier 1a (can be achieved with predicted supply)**			
	• Year-round low flow • Winter/spring high flow (one high flow)		• Year-round low flow • Winter/spring high flow (one high flow) • Autumn high flow (one high flow)	
	Tier 1b (supply deficit)			
	• N/A			
Potential environmental watering – tier 2 (additional priorities)	• Autumn high flow (one high flow)		• N/A	

Planning scenario	Drought	Dry	Average	Wet
Possible volume of water for the environment required to achieve objectives[6]	• 4, 000 ML (tier 1a) • 2,000 ML (tier 2)		• 6,000 ML (tier 1a)	
Serpentine Creek (targeting reach 1)[7]				
Potential environmental watering – tier 1 (high priorities)	**Tier 1a (can be achieved with predicted supply)**			
	• Winter/spring low flow (delivered at 10 ML/day) • Winter/spring fresh (one fresh, delivered at 40 ML/day) • Summer/autumn low flow (delivered at 10 ML/day) • Summer/autumn freshes (three freshes)	• Winter/spring low flow (delivered at 10 ML/day) • Winter/spring fresh (one fresh) • Summer/autumn low flow (delivered at 10 ML/day) • Summer/autumn freshes (three freshes)	• Winter/spring low flow (delivered at 10 ML/day) • Winter/spring fresh (one fresh) • Summer/autumn low flow (delivered at 10 ML/day) • Summer/autumn freshes (three freshes)	• Winter/spring low flow (delivered at 10 ML/day) • Winter/spring fresh (one fresh) • Summer/autumn low flow • Summer/autumn freshes (three freshes)
	Tier 1b (supply deficit)			
	• Winter/spring fresh (tier 1a fresh delivered at 120 ML/day) • Summer/autumn low flow (delivered at 10-20 ML/day) • Winter/spring low flow (delivered at 10-20 ML/day)	• Winter/spring low flow (delivered at 10-20 ML/day) • Summer/autumn low flow (delivered at 10-20 ML/day)	• Winter/spring low flow (delivered at 10-30 ML/day) • Summer/autumn low flow (delivered at 10-20 ML/day)	• Winter/spring low flow (delivered at 10-30 ML/day)
Potential environmental watering – tier 2 (additional priorities)	• N/A	• N/A	• N/A	• N/A
Possible volume of water for the environment required to achieve objectives	• 1,430 ML (tier 1a) • 3,700 ML (tier 1b)	• 1,430 ML (tier 1a) • 2,500 ML (tier 1b)	• 1,300 ML (tier 1a) • 3,200 ML (tier 1b)	• 1,160 ML (tier 1a) • 2,000 ML (tier 1b)
Priority carryover requirements for 2023-24	• 4,400 ML for early-season low flow and winter/spring high flow	• 4,000 ML for early-season low flow and winter/spring high flow		

1 Loddon system entitlements are shared between the Loddon River system and the Boort wetlands. Expected availability is used to meet demands in both systems.
2 Under a drought scenario, the VEWH may request a reduction in passing-flow volume at Loddon Weir and accumulate the savings for use at other times of the year. The combined volume in Cairn Curran and Tullaroop reservoirs must exceed 60,000 ML to enable passing-flow savings.
3 When passing flow can be accumulated or water availability allows, the winter/spring low flow magnitude may be increased to 50 ML/day to maintain seasonal variability, support vegetation and aquatic animals and prevent a decline in oxygen levels.
4 In 2022-23, it is expected that passing flow will be accumulated in winter/spring (when the combined volume in Cairn Curran and Tullaroop reservoirs exceeds 60,000 ML), providing sufficient water to deliver the winter/spring high flow. If the combined volume in storage is less than 60,000 ML, the winter/spring high flow will become a Tier 1b watering action.
5 If passing flow has been accumulated in winter/spring (when the combined volume in Cairn Curran and Tullaroop reservoirs exceeds 60,000 ML) or water availability allows, the summer/autumn low-flow magnitude may be increased to 40 ML/day.
6 Each environmental watering event in Pyramid Creek has an estimated demand of 2,000 ML for underwriting losses associated with delivering consumptive water en route to downstream locations via Pyramid Creek. The actual demand for each event is expected to be a much lower volume.
7 Delivery of low flow in Serpentine Creek is constrained below recommended flow rates until an approach to deal with end-of-system flow is agreed on.

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5.7.2 Boort wetlands

System overview

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

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

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

Environmental values

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

Environmental watering objectives in the Boort wetlands

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

Traditional Owner cultural values and uses

In planning for environmental flows in the Boort wetlands, North Central CMA has worked with Barapa Barapa and Wamba Wemba Traditional Owners and Dja Dja Wurrung Clans Aboriginal Corporation (trading as DJAARA) to identify opportunities to engage on environmental water planning and delivery, now and in the future.

The wetlands and surrounding land in the Boort region are rich in cultural heritage, with sites and artefacts of cultural practices present throughout the landscape. The rivers and floodplains are valued as food and fibre sources and contain many sites of significance (such as camp sites and meeting places). Environmental watering supports values such as native fish, waterbirds and turtles, and promotes the growth of culturally important plants that provide food, medicine and weaving materials. The presence of water itself can be a cultural value, as well as the quality of the water, as healthy water promotes a healthy Country.

The *Dhelkunya Dja (Healing Country) Country Plan 2014-2034* describes their aspirations around the management of rivers and waterways and articulates Dja Dja Wurrung peoples' support for the reinstatement of environmental flows as an overall objective for the management of water on Country.

Increasing the involvement of Traditional Owners in environmental water planning and management, and ultimately providing opportunities to progress towards self-determination within the environmental watering program, is a core commitment of the VEWH and its agency partners. This is reinforced by a range of legislation and policy commitments (for example the *Water*

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Act 1989, the Victorian Aboriginal Affairs Framework, *Water for Victoria* (2016)) and, in some cases, agreements under the *Traditional Owner Settlement Act 2010*. Where Traditional Owners are more deeply involved in the planning and/or delivery of environmental flows for a particular site, their contribution is acknowledged in Table 5.7.3 with an icon. The use of this icon is not intended to indicate that these activities are meeting all the needs of Traditional Owners but is incorporated in the spirit of valuing that contribution, and indicating progress towards this objective.

Watering planned and/or delivered in partnership with Traditional Owners to support cultural values and uses

DJAARA is completing a Water For Country 'Gatjin' Strategy to set the vision, objectives and targets for cultural water on Country. Aboriginal Waterway Assessments (AWAs) planned to be undertaken in 2022-23 will feed into the Strategy. Through the Water For Country 'Gatjin' Strategy DJAARA will integrate data from completed AWAs into water planning processes to better influence how water is managed on Country (such as through the Seasonal Watering Plan process).

The North Central CMA is committed to working with DJAARA including their local family group Yung Balug, to enable the proposed watering at Lake Boort while managing cultural heritage, to the satisfaction of all partners. This includes the inundation of culturally significant plant communities.

In early 2022, Barapa Barapa and Wamba Wemba Traditional Owners went on a field visit to Lake Leaghur, Lake Meran and Little Lake Meran. The group discussed which Boort and central Murray wetlands to water in 2022-23, and supported the proposal to water most of the actively managed wetlands on their Country and to allow Lake Yando to go through a dry phase. The group also indicated a preference to water Little Lake Meran over Lake Leaghur (if water supply is an issue) as the fringing black box trees are looking stressed. The group indicated that they are very interested in undertaking Aboriginal Waterway Assessments (AWAs) at several of the Boort wetlands in the future – in both wet and dry phases.

Social, recreational and economic values and uses

In planning the potential environmental flows in Table 5.7.3, North Central CMA considered how environmental flows could support values and uses, including:

- water-based recreation (such as fishing and water sports)
- waterway recreation and amenity (such as birdwatching, camping and duck hunting)
- community events and tourism (such as attracting locals and visitors for birdwatching and hunting)
- socio-economic benefits (such as aesthetic benefits for landholders and water levels and quality for flood mitigation, nutrient treatment and carbon storage).

Recent conditions

Rainfall across the Boort wetlands and the upstream catchment was close to the long-term average during 2021-22, and temperatures were above the long-term average. Allocations in the Loddon and Goulburn systems against high-reliability water shares rose from 33 percent at the start of July to 100 percent in October, but there were no allocations against low-reliability water shares. Loddon allocations were not enough to meet all environmental demands in the Loddon River and Boort wetlands in 2021-22, so the VEWH traded 5 GL of water from its entitlements in the Goulburn to the Loddon system.

Deliveries of water for the environment for the Boort wetlands were managed in line with an average climate scenario throughout 2021-22. Watering actions were planned for Lake Boort, Lake Meran and Lake Leaghur, but water for the environment was only delivered to Lake Meran and Lake Boort.

The winter/spring fill at Lake Meran was a high priority for 2021-22, and additional water to enable the delivery was sought from the Goulburn system. Capacity constraints in the irrigation supply channel limited the rate at which water could be delivered to the lake and prevented the target level from being achieved by the end of spring. Watering ceased during summer to avoid unseasonal inundation, but it resumed in autumn to inundate fringing river red gums and black box. Lake Meran will be allowed to draw down in 2022-23 and 2023-24 to support dry-phase ecosystem processes.

A low-level partial fill at Lake Boort commenced in autumn 2022 to prime the wetland before a higher partial fill is delivered in winter/spring 2022. This was the first time water for the environment has been delivered to Lake Boort, and it is the first inflow to the lake since the 2016 floods. The Lake Boort partial fill was planned in consultation with Dja Dja Wurrung and the local Yung Balug family group, and it aimed to support river red gums that were planted in 2017 and culturally important vegetation (such as spiny flat sedge).

Lake Leaghur received a priming fill in autumn 2021, and it held sufficient water throughout winter and spring to meet the environmental objectives for 2021-22. Delivering additional water in winter/spring would have potentially compromised river red gum saplings and cane grass that were planted at Lake Leaghur in 2019-20, so the planned watering action was cancelled. Trigger-based top-ups were also not required because no significant waterbird breeding was observed.

Lake Yando was filled in 2020-21, and Little Lake Meran last filled in 2019-20. Both wetlands were allowed to draw down in 2021-22 to support dry-phase ecosystem processes.

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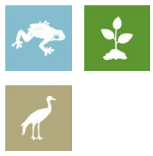
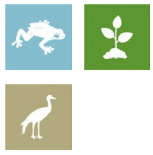
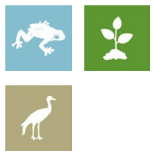
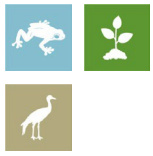
Scope of environmental watering

Table 5.7.3 describes the potential environmental watering actions in 2022-23, their expected watering effects (that is, the intended physical or biological effects of the watering action) and the longer-term environmental objectives they support. Each environmental objective relies on one or more potential environmental watering actions and their associated physical or biological effects.

Table 5.7.3 Potential environmental watering actions, expected watering effects and associated environmental objectives for the Boort wetlands

Potential environmental watering action	Expected watering effects	Environmental objectives
Lake Boort (partial fill in winter/spring, top-ups as required) 	• Increase the water depth around the wetland fringe (the target water level is 90.2 m AHD) to promote the germination and recruitment of fringing vegetation, including culturally significant species (such as spiny flat sedge) • Support the growth of aquatic and semi-aquatic plants within the wetland • Grow zooplankton and waterbug communities to provide food for waterbirds and frogs	
Lake Leaghur (partial fill in spring/summer or autumn/winter)[1]	• Provide increased habitat area and grow zooplankton and waterbug communities to provide food resources for frogs and waterbirds • A spring/summer partial fill will: - increase the water depth (the target water level is 84.4 m AHD) around the wetland fringe to promote the germination and recruitment of fringing vegetation (such as river red gums and cane grass) - support the growth of aquatic and semi-aquatic plants • An autumn/winter partial fill will: - prime the wetland for spring watering in 2023-24 by breaking the dormancy of aquatic vegetation propagules so they can grow and reproduce	
Lake Yando (top up to support waterbird breeding or vegetation outcomes if triggered by a natural flood or flood mitigation water)	• Wet the wetland fringe (the target water level is 87.6 m AHD) to promote the germination and recruitment of river red gums and black box and maintain the existing mature trees • Support the growth of aquatic and semi-aquatic plants • Provide habitat and food resources for aquatic animals • Grow zooplankton and waterbug communities to provide food for waterbirds and frogs	
Little Lake Meran (fill in winter/spring, top-ups as required)	• Wet the wetland fringe (the target water level is between 78.7 m AHD to 79.7 m AHD) to promote the growth and recruitment of river red gums and black box and maintain existing mature trees • Support the growth of aquatic and semi-aquatic plants • Grow zooplankton and waterbug communities to provide food for waterbirds and frogs	

1 An ecological assessment will occur at Lake Leaghur in spring 2022 to determine the best season to water this wetland based on observed environmental conditions, forecast climatic conditions, water availability and expected operational delivery constraints.

Scenario planning

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

The highest-priority action in the Boort wetlands in 2022-23 under all climate scenarios will be to continue the partial fill at Lake Boort that commenced in autumn 2022. That watering action aims to trigger the growth of aquatic vegetation, including many species that are culturally important to Traditional Owners. Additional top-ups may be required to ensure fringing river red gums are sufficiently inundated to improve their condition after being dry for more than five years.

Watering Little Lake Meran is a priority under dry to wet scenarios in 2022-23. Little Lake Meran was last watered in 2019-20, and it then underwent a drying phase. Watering Little Lake Meran in winter and spring 2022 will likely trigger the germination of aquatic plants and initiate a productivity boom of zooplankton and macroinvertebrates that will provide food for frogs and waterbirds. Subsequent top-ups may be required throughout the year to water fringing trees that have been dry for three years and support potential waterbird and frog breeding events. Watering Little Lake Meran is not a priority under a drought scenario, as the lake and its associated vegetation community can withstand up to two more years before their maximum recommended dry period is exceeded.

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Lake Leaghur may be partially filled in spring/summer or autumn/winter under average or wet climate scenarios. In the past decade, Lake Leaghur has had its minimum recommended watering regime and is currently in a rehabilitation phase. Delivering water for the environment in 2022-23 will build on environmental outcomes from its partial fill in autumn 2021. An ecological assessment will be conducted in spring 2022 to determine if Lake Leaghur needs to be watered this year and the best time to deliver water. The assessment will consider the wetland's condition, expected climatic conditions over summer/autumn and potential delivery constraints, including concurrent deliveries to other Boort wetlands and the Loddon River. Filling Lake Leaghur is a low priority under drought and dry scenarios because the watering event in 2021 has maintained the minimum required watering regime.

Lake Yando may flood naturally under a wet climate scenario or receive flood mitigation water. If either of these things occurs, water for the environment may be used to top up the water level and/or extend the inundation period, to support waterbird breeding and allow wetland vegetation to complete their life cycles through spring and summer.

Lake Meran will be allowed to draw down during 2022-23 to support dry-phase ecosystem processes in accordance with the recommended water regime in the *Meran Lakes Complex Environmental Water Management Plan*.

Priority carryover requirements for 2023-24 focus on completing any watering actions that commence in autumn/winter 2023. A carryover target of 500 ML has been set under scenarios where Lake Leaghur is likely to be watered. The final carryover requirements will be revised during the year once the likely status of planned watering actions becomes clear.

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

Planning scenario	Drought	Dry	Average	Wet
Expected conditions	• No natural inflow to wetlands	• Minimal natural inflow to wetlands from local catchment run-off is possible	• Moderate inflow from local catchment run-off, but little if any inflow from nearby creeks or flood runners	• Extended durations of high flow and overbank flow from creeks and flood runners, which fill most wetlands
Expected availability of water for the environment[1]	• 18,002-23,745 ML	• 21,568 ML	• 21,568 ML	• 21,568 ML
Potential environmental watering – tier 1 (high priorities)	**Tier 1a (can be achieved with predicted supply)**			
	• Lake Boort (partial fill in winter/spring, top-ups as required)	• Lake Boort (partial fill in winter/spring, top-ups as required) • Little Lake Meran (fill in winter/spring, top-ups as required)	• Lake Boort (partial fill in winter/spring, top-ups as required) • Lake Leaghur (partial fill in spring/summer or autumn/winter) • Little Lake Meran (fill in winter/spring, top-ups as required)	• Lake Boort (partial fill in winter/spring, top-ups as required) • Lake Leaghur (partial fill in spring/summer or autumn/winter) • Little Lake Meran (fill in winter/spring, top-ups as required)
	Tier 1b (supply deficit)			
	• N/A	• N/A	• N/A	• N/A
Potential environmental watering – tier 2 (additional priorities)	• N/A	• Lake Leaghur (partial fill in spring/summer or autumn/winter)	• N/A	• Lake Yando (top up if triggered)
Possible volume of water for the environment required to achieve objectives	• 5,000 ML (tier 1a)	• 6,400 ML (tier 1a) • 600 ML (tier 1b)	• 7,000 ML (tier 1a)	• 6,800 ML (tier 1a) • 600 ML (tier 2)
Priority carryover requirements for 2023-24	• N/A	• 500 ML[2]	• 500 ML[2]	• 500 ML[2]

1 Loddon system entitlements are shared between the Loddon River system and the Boort wetlands.
2 Priority carryover of 500 ML is required for delivery to Lake Leaghur if the partial fill is delivered in autumn/winter 2023.

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5.7.3 Birchs Creek

System overview

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

Birchs Creek is part of the broader Bullarook system, which contains two small storages — Newlyn Reservoir and Hepburn Lagoon — that provide water for irrigation and urban supply. The storages fill and spill during winter or spring in years with average or above-average rainfall. The VEWH holds water for the environment in Newlyn Reservoir, but there is no water held in Hepburn Lagoon.

Birchs Creek receives tributary inflows from Rocky Lead, Langdons, Lawrence and Tourello creeks. Groundwater provides reliable baseflows to the downstream reaches of Birchs Creek in most years.

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

Environmental values

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

Anecdotal reports suggest the removal of willows along the creek in 2018 has improved in-stream vegetation and habitat for populations of small-bodied fish.

Environmental watering objectives in Birchs Creek

Icon	Environmental objectives in Birchs Creek
	Increase the abundance and diversity of small- and medium-bodied native fish, including river blackfish, mountain galaxias, flat-headed gudgeon and Australian smelt
	Increase the platypus population and improve its resilience to future droughts andfloods Provide surplus juvenile platypus that can disperse to Creswick and Tullaroop creeks
	Maintain the diversity and increase the abundance of in-stream aquatic plants Maintain a diverse variety of fringing and streamside native vegetation communities
	Increase the population of waterbugs and the diversity of functional groups to drive productive and dynamic food webs
	Maintain water quality to support aquatic life and ecological processes

Traditional Owner cultural values and uses

In planning for environmental flows in Birchs Creek, Dja Dja Wurrung Clans Aboriginal Corporation (trading as DJAARA) and North Central CMA have identified the creek as a potential site for future projects.

The *Dhelkunya Dja (Healing Country) Country Plan 2014-2034* describes their aspirations around the management of rivers and waterways and articulates Djaara's (Dja Dja Wurrung peoples') support for the reinstatement of environmental flows as an overall objective for the management of water on Country.

The North Central CMA and DJAARA continue to work towards increased engagement on planning and delivery of environmental watering activities, including identifying opportunities for Dja Dja Wurrung to play a greater role in the management and administering of environmental water.

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Social, recreational and economic values and uses

In planning the potential watering actions in Table 5.7.5, North Central CMA considered how environmental flows could support values and uses, including:

- water-based recreation (such as fishing)
- riverside recreation and amenity (such as cycling and walking [particularly in Newlyn, Smeaton and Clunes] and improved amenity at key community spaces like Anderson's Mill)
- improved water quality (such as for domestic and stock use).

Recent conditions

Rainfall in the Birchs Creek catchment during 2021-22 was above the long-term average. Water for the environment allocated in December 2020 was carried over into 2021-22, but it was lost due to spills from Newlyn Reservoir through winter and spring in 2021. These spills produced three distinct high flows in the winter/spring period, with the largest event peaking at 447 ML per day at Smeaton in early September 2021. Another spill in January provided a large summer fresh that reached 254 ML per day at Smeaton. Seasonal determinations against high-reliability water shares in the Bullarook system opened at 40 percent allocation on 1 July 2021 and reached 100 percent allocation by mid-July. The VEWH was allocated the full 100 ML volume on 1 December 2021.

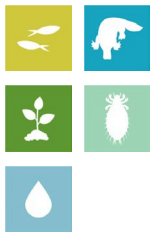
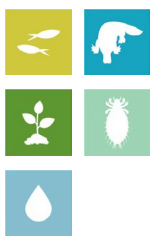
The Bullarook system was managed in line with an average climate scenario throughout 2021-22. All planned watering actions for the year were met or exceeded through natural flows, including groundwater baseflows, spills from storage and consumptive releases. The allocation from December 2021 will be carried over to support watering actions in 2022-23.

A census of platypus and river blackfish in Birchs Creek was undertaken in 2021-22 using environmental DNA. The methods replicated a survey conducted in 2015-16, and the results indicate that platypus and river blackfish have increased their distribution and are now present at more sites throughout the system. Platypus also appear to have dispersed into Creswick Creek and Tullaroop Creek.

Scope of environmental watering

Table 5.7.5 describes the potential environmental watering actions in 2022-23, their expected watering effects (that is, the intended physical or biological effects of the watering action) and the longer-term environmental objectives they support. Each environmental objective relies on one or more potential environmental watering actions and their associated physical or biological effects.

Table 5.7.5 Potential environmental watering actions, expected watering effects and associated environmental objectives for Birchs Creek

Potential environmental watering action	Expected watering effects	Environmental objectives
Birchs Creek (targeting reach 2)[1]		
Winter/spring fresh (one to four freshes of 27-30 ML/day for three to five days during June to November)	• Maintain and support the growth and germination of streamside vegetation by increasing soil moisture and depositing sediment on the bank and benches • Scour old biofilms and organic matter that has accumulated in the channel, and cycle nutrients throughout the creek • Improve water quality by freshening refuge pools and provide connectivity between pools for fish and platypus movement	
Summer/autumn fresh(es) (one to four freshes of 10-15 ML/day for three days during December to May)	• Increase the water depth to maintain and support seed germination and the growth of in-stream aquatic vegetation • Improve the condition of riffle/run habitats for waterbugs • Top up pools to refresh water quality (particularly oxygen levels) and enhance connectivity between pools for fish and platypus movement	

1 Environmental flows target outcomes in reach 3, but compliance can only be assessed in reach 2.

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Scenario planning

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

The water for the environment in Birchs Creek is primarily used to deliver winter/spring freshes and summer/autumn freshes, where they are not met by natural flows or consumptive water deliveries. The volume of available water for the environment is not sufficient to deliver any of the other environmental flows that are recommended for the system. The Birchs Creek Environmental Water Advisory Group (which recently combined with the Tullaroop Catchment Restoration Plan Project Reference Group) and ecologists have advised available water for the environment should be used to deliver recommended freshes in full, rather than a small proportion of recommended low flows.

Winter/spring freshes are important for cycling nutrients throughout the system and wetting higher channel features to increase connectivity between habitat types for aquatic animals. Summer/autumn freshes are needed to maintain water quality over the warmer months and ensure pools do not dry out.

Regular winter/spring freshes are important to cycle nutrients throughout the system and wet higher channel features to increase connectivity between habitat types for aquatic animals. Summer/autumn freshes are needed to maintain water quality in the warmer months and ensure pools do not dry out. However, both watering actions are important, and if required and where allocation allows, summer/autumn freshes may be prioritised to avoid critical loss of environmental values when the system is likely to be under the greatest stress. Summer/autumn freshes should be delivered at the upper magnitude where possible, either by augmenting natural or consumptive flows or by using water for the environment to deliver greater-magnitude freshes after one fresh has been met naturally. Under a drought scenario, the environment is unlikely to receive its allocation in December, so carryover from 2021-22 should be used to deliver a winter/spring fresh before the water is forfeited on 30 November. Winter/spring freshes will likely be delivered naturally by reservoir spills under average and wet climate scenarios.

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

Planning scenario	Drought	Dry	Average	Wet
Expected creek conditions	• Reservoir is unlikely to spill • Extremely low flow in winter/spring • Limited irrigation releases due to low allocations	• Reservoir spill is possible • Low flow in winter/spring if no spills occur • Moderate irrigation releases	• Reservoir spills are certain in winter/spring • Some natural flow through summer/autumn • Groundwater contributes to baseflow throughout the year	• Reservoir spills are certain in winter/spring • Natural flow through summer/autumn • Groundwater contributes to baseflow throughout the year
Expected availability of water for the environment	• 100 ML (2021 carryover)	• 100-200 ML (2021 carryover and likely 2022 allocation)	• 100 ML (2022 allocation)[1]	• 100 ML (2022 allocation)[1]
Birchs Creek (targeting reach 2)				
Potential environmental watering – tier 1 (high priorities)	**Tier 1a (can be achieved with predicted supply)**			
	• Winter/spring fresh (one fresh for three days)	• Winter/spring fresh (one fresh for three days) • Summer/autumn fresh(es) (one to three freshes, lower magnitude)	• Winter/spring fresh (one fresh for three days) • Summer/autumn fresh(es) (one to three freshes, lower magnitude)	• Winter/spring freshes • Summer/autumn freshes (three freshes)
	Tier 1b (supply deficit)			
	• Summer/autumn freshes (three freshes)	• Summer/autumn freshes (deliver tier 1a freshes at upper magnitude)	• Winter/spring fresh(es) (one to four freshes for five days) • Summer/autumn fresh(es) (one to four freshes, deliver tier 1a freshes at upper magnitude)	• Summer/autumn fresh(es) (one to four freshes, deliver tier 1a freshes at upper magnitude)

Planning scenario	Drought	Dry	Average	Wet
Potential environmental watering – tier 2 (additional priorities)	• N/A			
Possible volume of water for the environment required to achieve objectives	• 81-90 ML (tier 1a) • 135 ML (tier 1b)	• 171-180 ML (tier 1a) • 45 ML (tier 1b)	• 90 ML (tier 1a) • 690 ML (tier 1b)	• 0 ML (tier 1a) • 180 ML (tier 1b)
Priority carryover requirements for 2023-24	• If the 100 ML allocation is received on 1 December 2022 and water for the environment is not required to achieve summer/autumn freshes, carry over 100 ML allocation into 2023-24 for use by 30 November 2023.			

1 Under an average or wet scenario, it is likely that Newlyn Reservoir will spill before 30 November 2022, losing the 100 ML carryover from December 2021.

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