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Chapter 13 Victorian Rivers Water Plan

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Acknowledgement of the Traditional Owners of the Murray–Darling Basin

The Commonwealth Environmental Water Office respectfully acknowledges the Traditional Owners, their Elders past and present, their Nations of the Murray–Darling Basin, and their cultural, social, environmental, spiritual and economic connection to their lands and waters.

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13.1 Region overview

13.1.1 River system

The Victorian rivers in the Murray-Darling Basin include the Goulburn-Broken, Campaspe, Loddon, Ovens and Wimmera catchments (Map VR1 and Map VR2). The northern Victorian rivers, particularly the Ovens and Goulburn-Broken, contribute significantly to the water resources of the River Murray. Although part of the Victoria rivers region, the Wimmera River in central-west Victoria flows into a series of terminal lakes, including Hindmarsh and Albacutya, and does not connect to the River Murray.

Around 20% of the basin's total water resources originate in the northern Victorian rivers (MDBA 2020). Lake Eildon on the Goulburn River is one of the Basin's major water storages, with a capacity of around 3,334 GL (GMW 2021). The region has a highly developed agricultural sector and a population of almost half a million people (DELWP 2019).

13.1.2 Traditional Owners

Aboriginal people have had a long association with the river valleys of northern and central Victoria (MDBA 2020). The Commonwealth Environmental Water Office (CEWO) respectfully acknowledges these Nations, their Elders past and present, as the Traditional Custodians of the lands on which this chapter is focused:

- The Ovens River catchment falls in the traditional lands of the Bangerang nation and neighbouring Taungurung and Yorta Yorta nations, to the south and west, respectively. The Waywurru nation is also located within the Ovens River valley
- The Aboriginal people of the northern plains of the Goulburn and Broken catchments are the Yorta Yorta and Bangerang Nations. The Taungurung is the main Nation of people in the Broken River Valley and upper Goulburn Valley
- West of the Campaspe River is the traditional land of the Dja Dja Wurrung Nation and east is the land of the Taungurung Nation. On the plains north of Rochester, the area is the traditional land of the Yorta Yorta and Bangerang Nations
- Most of the Loddon catchment and the Avoca catchment is the traditional land of the Dja Dja Wurrung Aboriginal nation. On the floodplains, around Kerang and Kow Swamp, is the traditional land of the Barapa Barapa nation
- The Wimmera catchment is large and diverse, and covers the traditional country of several Aboriginal Nations, including the Dja Dja Wurrung, Wotjobaluk and Wergaia in the mid and lower catchment. The north of the catchment, towards the River Murray, is the traditional lands of the Latji Latji, Tatti Tatti and Wamba Wamba Nations.

13.1.3 Important sites and values

The northern Victorian rivers are identified in the Basin-wide environmental watering strategy (MDBA 2019) as being important Basin environmental assets for native fish, including supporting high fish diversity and as a fish refuge during dry periods. They create key native fish movement corridors and are recognised as priority sites for improving the core range of numerous threatened species, notably the nationally threatened silver perch.

These rivers also support additional species and communities listed under the *Environment Protection and Biodiversity Conservation Act 1999*. Faunal species include Murray cod, Macquarie perch, trout cod, Australasian bittern, swift parrot and the growling grass frog*;* vegetation includes rigid water milfoil and box-dominated grassy woodland communities*.*

The river system also supports bird species listed under international migratory species agreements (such as those agreements with Japan, China and the Republic of Korea, and the Ramsar convention). Protected species observed in the Victorian river system include the sea eagle, Australasian bittern, brolga, royal spoonbill, yellow-billed spoonbill, Australasian shoveler, eastern great egret, white-bellied sea eagle, glossy ibis and Latham's snipe.

Located at the terminus of the Wimmera system is the Lake Albacutya Ramsar wetland. This internationally listed wetland only receives water in exceptionally wet years. Further, the Kerang Wetlands Ramsar site is located at the junction of three major floodplains associated with the Avoca, Loddon and Murray rivers, and is hydrologically linked to the Loddon River. Several sites are listed in the Directory of Important Wetlands in Australia including the Broken River, Upper Broken Creek, Lower Ovens River, Wimmera River, Lake Hindmarsh and Moodie Swamp.

The delivery of environmental water to the northern Victorian rivers also supports ecological values and outcomes in the River Murray valley. This includes Ramsar-listed wetlands such as the Barmah Forest, Gunbower Forest, Hattah Lakes, and the Coorong, Lower Lakes and Murray Mouth.

13.1.4 Stakeholder engagement

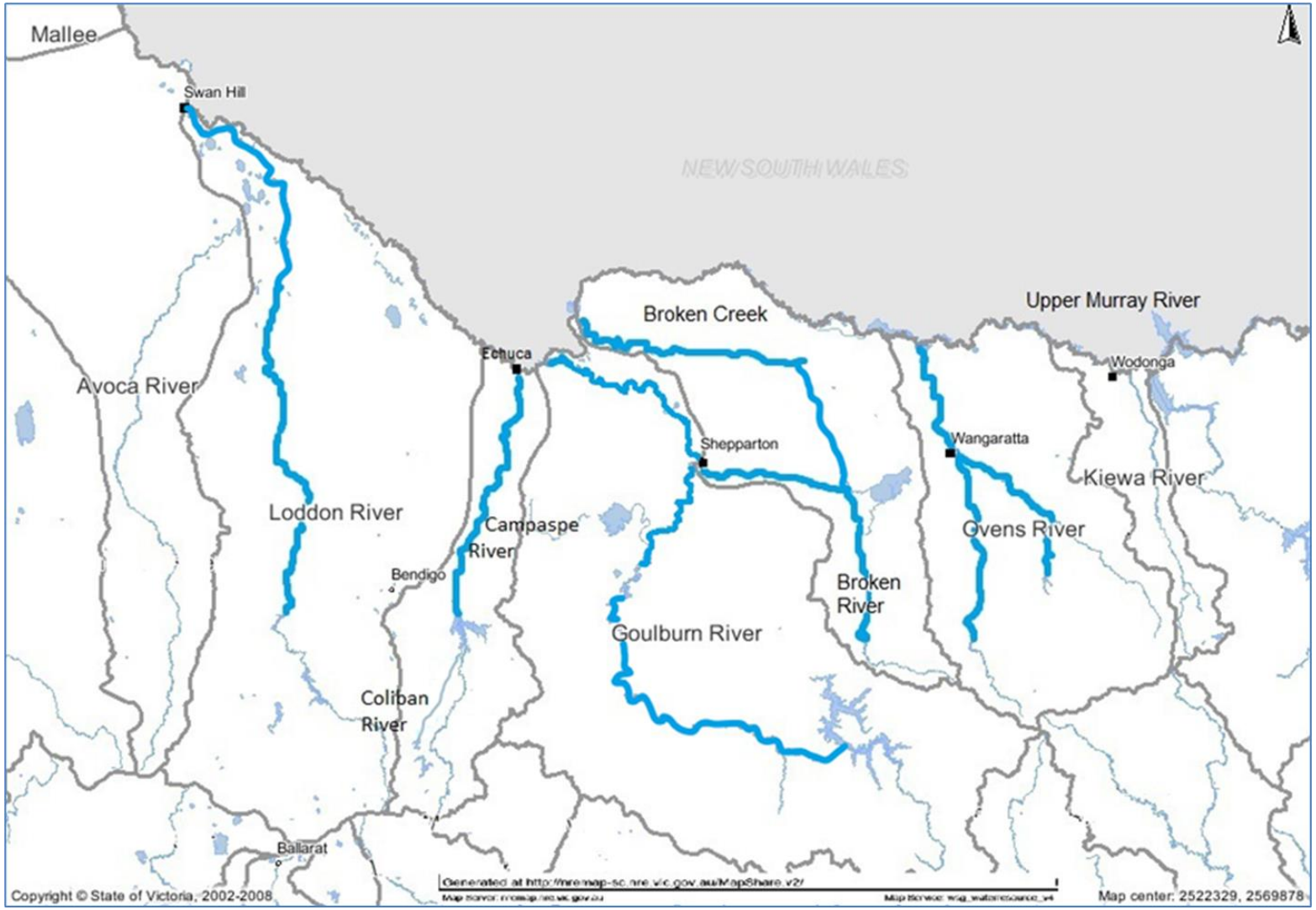
The planning, management and delivery of Commonwealth water for the environment throughout the northern Victorian valleys is undertaken in collaboration with a range of partners and stakeholder groups, including both government and non-government entities.

The implementation of watering actions within the Victorian rivers is coordinated by the Victorian Environmental Water Holder (VEWH) and managed by regional waterway managers including the Goulburn-Broken Catchment Management Authority (GBCMA), North Central Catchment Management Authority (NCCMA), North East Catchment Management Authority (NECMA) and Wimmera Catchment Management Authority (WCMA). Goulburn Murray Water (GMW) is the principal storage and water supply manager in northern Victorian catchments and is responsible for the day-to-day delivery of water (including environmental water) throughout its river systems and irrigation supply network. Grampians Wimmera Mallee Water (GWMW) is the storage and water supply manager for the Wimmera catchment.

Early input to the potential watering actions for 2021–22 was received via the Environmental Watering Advisory Group meetings organised and chaired by the NCCMA and the GBCMA. Membership includes government agencies, land holders, community members and representatives from the Yorta Yorta, Taungurung, Dja Dja Wurrung and Barapa Bapara-Wemba Wamba Nations.

Delivery partners and the CMAs attended workshops to review the 2020–21 watering events, including to identify any risks that arose, and discuss mitigating actions going into 2021–22. Feedback on excerpts of this Water Management Plan were provided by the VEWH and the CMAs and incorporated into the final version.

Map VR1 Northern Victorian rivers



Source: CEWO (2020)

Map VR2 Victorian Wimmera system

13.2 Environmental objectives

The objectives in

Table VR1 are relevant for environmental watering in Victorian Rivers. They are based on long-term environmental objectives in the Basin Plan, Victorian state government long-term watering plans, site management plans, and best available knowledge. The following objectives are relevant for environmental watering in the Victorian Rivers.

The objectives that are targeted in a particular year may vary, depending on available water, catchment conditions, operational feasibility, and demand for environmental water. These objectives will continue to be revised as part of the Commonwealth Environmental Water Office's (CEWO) commitment to adaptive management.

Table VR1 Summary of objectives being targeted by environmental watering in the Victorian rivers

Basin-wide Matters	In-Channel Assets	Off-Channel Assets
Vegetation	Re-establish/maintain and improve riparian and in-channel vegetation cover, extent, condition and diversity. Increase periods of growth for inundation tolerant vegetation communities that closely fringe or occur within river channels.	Maintain the current extent, condition and diversity of water-dependent vegetation. Improve condition of black box, river red gum and lignum shrublands. Improve recruitment of trees within black box and river red gum communities.
Waterbirds	Provide habitat and food sources to support waterbird breeding, survival and recruitment, and maintain condition and current species diversity.	Support waterbird breeding, including brolga in Moodie Swamp.
Fish	Provide flows to support habitat and food sources to promote increased movement, breeding, recruitment and survival of native fish. Improve abundance and maintain species richness. Provide native fish passage through fishways.	Provide flow cues to support habitat and food sources and promote increased movement, recruitment and survival of native fish (particularly for floodplain specialists).
Invertebrates	Provide habitat to support increased microinvertebrate and macroinvertebrate survival, diversity, abundance and condition.	Same as in-channel.
Other Vertebrates	Provide habitat and food sources to support survival, maintain condition and provide recruitment opportunities for frogs, turtles, platypus and native water rats (Rakali).	Same as in-channel.
Connectivity	Support longitudinal connectivity along Victorian rivers and to the River Murray for environmental functions such as nutrient and sediment transport, organism dispersal and water quality. Support lateral connectivity to low-lying wetlands and anabranches adjacent to river channel by increasing the frequency of freshes.	Support lateral connectivity (within operational limits) to wetlands and floodplains by contributing to an increase in the frequency of lowland floodplain flows.
Processes	Support primary productivity, sediment, nutrient and carbon transport and cycling; biotic dispersal/movement; and channel maintenance. Minimise erosion and mass-failure and reintroduce sediments/seed.	Same as in-channel.

Basin-wide Matters	In-Channel Assets	Off-Channel Assets
Water Quality	Maintain water quality and provide refuge habitat from adverse water quality events (e.g. low dissolved oxygen, hypoxic blackwater and hypersalinity), including minimising accumulation of Azolla (aquatic plant) in lower Broken Creek to help maintain DO levels.	Support the transport of nutrients and carbon off the floodplain and into the river channel and downstream.
Resilience	Provide drought refuge habitat.	Same as in-channel.

In-channel assets: Goulburn (lower and middle reaches), Broken, Campaspe, Loddon, Ovens and Wimmera rivers; Upper and lower Broken Creek. **Off-channel assets**: Goulburn River wetlands; Lower Broken wetlands; Upper Broken Creek wetlands (Moodie Swamp); Ovens wetlands (Mullinmur Billabong).

13.3 First Nations environmental watering objectives

The CEWO is committed to working with First Nations groups to better understand their objectives. For example, the CEWO has funded Taungurung Land and Waters Council and Goulburn-Broken Catchment Management Authority to identify off-channel wetlands in the mid-Goulburn where management of water could jointly achieve ecological and cultural objectives. The VEWH Seasonal Watering Plan for 2021–22 (VEWH 2021) identifies Traditional Owner cultural values and uses for each of the valleys within Northern Victoria. These site and valley-based objectives and planning will work hand-in-hand with broader system scale objectives and outcomes identified in the *Statement on environmental water use in 2021–22* made by participants at the Southern Basin First Nations' Environmental Watering Forum 2021 (see Chapter 2).

The CEWO will use environmental flows to contribute to these objectives where possible and where this is consistent with the Commonwealth Environmental Water Holder's statutory responsibility of protecting and restoring environmental assets in the Basin. The CEWO is committed to improving our direct engagement with Traditional Owners and recognises there are many areas for improvement in this space.

13.4 Recent conditions and seasonal outlook

13.4.1 Recent conditions and environmental water use

The health of the Victorian rivers in the Murray-Darling Basin reflects 15 years of harsh climate conditions. Over this period there was prolonged drought between 1997 and 2010, significant flooding in 2010 and 2011, wet conditions in 2012–13 and a subsequent series of three moderate to dry years until 2016–17 which was wet. Dry years followed in 2017–18 to 2019–20 with dry to moderate conditions in 2020–21. Environmental watering in northern Victoria has focused on supporting year-round low flows along with higher in-channel flows (such as freshes) in winter and spring. This has contributed to positive ecological outcomes such as maintaining vegetation condition along riverbanks and riparian zones, improved water quality and providing habitat for water bugs and native fish. However, in the last four years large volumes of operational water have been delivered over the summer months in the Campaspe and Goulburn Rivers to meet the need of downstream users (known as inter-valley transfers). This has caused bank erosion and damage to vegetation on the lower parts of the riverbanks in these catchments.

Impacts of historical dry conditions across the northern Victorian catchments mean that many of the sites continue to require water for the environment to maintain the ecological health of the waterways and have high demand, as outlined in Table VR3.

Learn more about the use of Commonwealth environmental water in Victorian Rivers.

13.4.2 Seasonal outlook

According to the Bureau of Meteorology outlook (BoM 2021), across northern Victoria there is largely a 75-80% chance of above median rainfall from July to September 2021.

This forecast indicates the continuation of wetter conditions following the end of last water year. Additionally, across northern Victoria there is a 50% chance or less of exceeding median max temperature across July to September.

13.4.3 Water availability

Allocations against Commonwealth water entitlements in the Victorian rivers are determined by the Victorian Government and will vary depending on inflows. The following forecasts in Table VR2 are based on the best available information including state forecasts and historical inflow scenarios.

Table VR2 Carryover and forecast allocation of Commonwealth environmental water for Victorian rivers in 2021–22

Valley	Carryover from 2020–2021 (GL)	Forecasts of Commonwealth water allocations (including carryover) in 2021–22 (GL)	
		Very dry	Very wet
Goulburn	190.9	369.3	551.9
Upper Broken Creek and Broken River	0	0.1	0.5
Campaspe	2.0	4.0	8.6
Loddon	1.4	2.8	3.9
Ovens	0	0.1	0.1
Wimmera	0	0	0
Southern-connected Basin	538	1,381	2,070

Note: The Southern-connected Basin is the network of rivers that feed into the Murray River between the Hume Dam and the sea. This includes the lower Darling/Baaka, Murrumbidgee, Murray, Ovens, Goulburn-Broken, Campaspe and Loddon valleys.

13.4.4 Environmental demands

Not all environmental demands can and will be met using held environmental water. Some demands are met by regulated water deliveries for consumptive purposes and inter-valley transfers, while others are met by large unregulated, natural flow events or are beyond what can be delivered within current operational limits. There may be opportunities for Basin State governments to relax these limits, which will improve the efficiency and/or effectiveness of environmental watering.

For the environmental water demands for assets in Victorian Rivers in 2021–22 see Table VR3.

The CEWO works closely with the VEWH and the CMAs to deliver its water and the information in this table is consistent with their planning documents referenced at GBCMA 2021a, GBCMA 2021b, GBCMA 2021c, GBCMA 2021d, NCCMA 2021a NCCMA 2021b, NECMA 2021, VEWH 2021, Wimmera 2021.

Table VR3 Environmental demands and watering priorities, 2021–22, and outlook for coming year, Victorian Rivers catchment

Environmental assets	Target values	Indicative demand (for all sources of water in the system)		Watering history (from all sources of water)	2021–22		Implications for future demands
		Flow/volume	Required frequency (maximum dry interval)		Environmental demands for water (all sources)	Potential Commonwealth environmental water contribution?	Likely urgency of demand in 2022–23 if watering occurred as planned in 2021–22
Goulburn River *Reach 4 Goulburn Weir to Loch Garry; and reach 5 Loch Garry to the River Murray* • Native fish - Murray cod, trout cod, Macquarie perch, golden perch and freshwater catfish • Bank vegetation, especially littoral vegetation and river red gum trees that shade the river and provide: habitat for animals including the squirrel glider; carbon from fallen leaves; habitat for birds such as egrets, herons and cormorants. • Frogs also benefit from inundated vegetation at the edge of the river channel. • Waterbugs • Platypus and turtles During the past three years very high volumes of intervalley transfer water has impacted on the planned deliver of e-water and this may continue during 2021–22 as part of the trial of the new operation rules.	Providing variable base flow will contribute to sustaining the system including for: • fish passage • increasing the width of literal zone vegetation for fish and water bug habitat • instream productivity to feed water bugs which feed fish, turtles and platypus.	Lowflow: year-round - variable 600–1000 ML/day. When higher volumes are available the upper end of the range will be delivered	Ever year under all climate scenarios to increase the required minimum passing flow of 200-400 ML/day.	Minimum low flows have been delivered every year since the Millennium drought.	High	High – with volumes depending on contributions from natural or operational flows throughout the year	High
	Recession flows to slow rapid fall in river levels and aims to: • reduce damage to the banks from mass failure (slumping) • bring sediment and propagules into the river.	Recession flow: when required - to slow the recession of natural flows and releases from Goulburn Weir. Commence flow at • 3,000 ML/day and below in summer /autumn when event magnitudes are lower and rates of fall are slower • 6,000 ML/day and below in winter/spring when event magnitudes are higher and rates of fall are more rapid	Every year when required, likely frequency depending on the climate scenario: • extreme dry and dry – no event • below Average – one event for winter/spring • average – one event for summer/autumn and one event for winter/spring • wet - two events for summer/autumn and two events for winter/spring	A standing order for recession flows was introduced in 2020–21.	High	High – with volumes depending on the number of unplanned high flow events	High
	The winter fresh aims to: • provide cues to platypus to build their nests higher on the bank to prevent later flooding • start channel forming processes if flows are over 7,500 ML/day and increase with the magnitude of the action • benefit lamprey migration from South Australia when delivered during July/August	Fresh: winter (July-Aug 2021 and May-June 20122) >7,300 ML/day for two days (or as high as possible)	Every year except under an extremely dry climate scenario (99% POE)	The winter fresh was first delivered in 2014–15, then not delivered in 2015–16 due to low water availability. It was delivered in each year between 2016–17 and 2018–19 but not in 2019–20 due to low water availability. In 2020–21 natural freshes up to 8,500 ML met this target.	High	High	High
	Variable flows which utilise mid-Goulburn tributary flows between the end of the winter fresh and the early spring fresh will: • improve abundance of macroinvertebrates • maintain lower and mid-bank vegetation • increase instream habitat complexity e.g. movement of sediment through the system and maintenance of deep pools	Variable flows: winter/spring - Achieve variability with flows up to 5,000 ML/d when flows in reach 3 are above 4,000 ML/d	Every year according to the climate conditions: • variable flows only in dry to wet scenarios. Can be delivered in a drought scenario if supply is available	This is the first year this flow action has been included in the Water Management Plan.	High	High	High

Environmental assets	Target values	Indicative demand (for all sources of water in the system)		Watering history (from all sources of water)	2021–22		Implications for future demands
		Flow/volume	**Required frequency (maximum dry interval)**		**Environmental demands for water (all sources)**	**Potential Commonwealth environmental water contribution?**	**Likely urgency of demand in 2022–23 if watering occurred as planned in 2021–22**
	An early spring fresh provides the best ecological benefit of all freshes as it primes the system and drives the food cycle by: • providing conditions for lower bank vegetation establishment and maintenance by: transporting plant propagules, increasing moisture in bank soils, driving germination, establishing new plants and encouraging the growth of existing plants • scouring and transport of fine sediment and biofilms which improves macroinvertebrate habitat. • provides cues for spawning and migration for flood specialist native fish.	Fresh: early spring (over Sept and Oct) Up to 10,500 ML/day with 7 days >7,300 ML/day	At least one every year in all climate scenarios	An early spring flow was delivered in 2012–13, not delivered in 2013–14 and partially met during 2014–15 and 2015–16. It has been delivered in every year since 2016–17 and including 20–21.	High	High	High
	Low flows after the spring fresh will allow: • littoral and lower bank vegetation to germinate and establish prior to a late spring fresh or summer high IVT deliveries • this vegetation to be maintained for more than one season.	Lowflow: after the early spring fresh <1,000 ML/day for as long as possible (6-8 weeks) This is a prerequisite for the delivery of a late spring fresh	1 in 2 to 4 years	Partially achieved in 2019–20, the first year it was included as a flow requirement. Prior to that it had not been met since 2016. Not met in 2020–21 due to frequent high natural flows during winter and spring.	This is a demand to not provide water above a given flow rate	This is a demand to not provide water above a given flow rate	This is a demand to not provide water above a given flow rate
	A late spring fresh when water temperature is over 19°C will: • provide cues for golden perch spawning if delivered in Nov/Dec • provide cues for silver perch spawning if delivered in Dec • scour old biofilms from hard substrates, resetting them and improving food resources for macroinvertebrates • transport fine sediments, helping to maintain instream habitat	Fresh: late spring (Nov or Dec) > 6,000 ML for 2 days >7,500 ML/d for greatest spawning response >5,600 ML/d for any benefit	Under an average or wet climate scenario and if • there has been 6 to 8 weeks of lowflows of around 1,000 ML/day prior to delivery or; • lower bank vegetation has not been inundated for less than a week Can also be delivered under drought to below average scenarios if supply is available, subject to the above conditions	A late spring fresh was delivered from 2012–13 to 2014–15 but with dry conditions in 2015–16 it was not delivered. In 2016–17 fish spawning objectives were met by natural flows so the fresh was not delivered to protect low bank vegetation after prolonged periods of high natural flows. It was delivered in 2017–18 but not in 2018–19 and 2019–20 due to the need for a drying phase for bank vegetation ahead of expected higher summer operational flows. This fresh was delivered in 2020–21.	Moderate – as delivered in 2020–21	High- if a decision is made to deliver the action	Moderate

Environmental assets	Target values	Indicative demand (for all sources of water in the system)		Watering history (from all sources of water)	2021–22		Implications for future demands
		Flow/volume	Required frequency (maximum dry interval)		Environmental demands for water (all sources)	Potential Commonwealth environmental water contribution?	Likely urgency of demand in 2022–23 if watering occurred as planned in 2021–22
	The autumn fresh should not be in the same area of bank targeted by IVT delivery over spring/summer and be of a higher magnitude. A fresh during autumn may: • encourage germination of new seed on the lower banks and benches and maintain existing vegetation • provide moisture and nutrients to mid-bank vegetation following low flows over summer • stimulate plant growth to stabilise the banks following IVT delivery over summer. • improve water quality • provides cues for fish movement through the system allowing dispersal • promote the migration of juvenile golden and silver perch into the if Murray River flows are relatively low • scour old biofilms from hard substrates, resetting them and improving food resources for macroinvertebrates • transport fine sediments and maintain instream habitat	Fresh: autumn (Between March and May) >5, 700 ML/day for 2 days	Every year in all climate scenarios, • If the IVT pulses have not delivered the fresh required and if • flows over summer and autumn have not exceeded 2000 ML/day for more than 20 days.	An autumn fresh was delivered from 2012–13 to 2015–16. It was not delivered in 2016–17 or 2017–18 after a fish attractant flow in those years. This fresh was not delivered in 2018–19 due to the already high volumes delivered as intervalley transfers and in 2019–20 due to dry conditions and low water availability. It was delivered in 2020–21.	High	High - depending on IVT demand	High
Goulburn River *Reach 1 Lake Eildon to Goulburn Weir* • Native fish – river blackfish • Platypus • Rakali (native water rat) • Turtles • Waterbugs • Vegetation • Macquarie perch Only receives water when it is released from Lake Eildon	A winter fresh aims to increase platypus populations. The platypus nesting period is September to November and the timing of this flow is to provide cues for platypus to build nests high on the bank to avoid drowning of nests during the higher spring flows	Fresh: winter 5,000 ML/day for 2 days	Every year whenever releases from Lake Eildon are low, likely in extremely dry, average and wet climate scenarios	This is the first year that this flow action has been planned.	High	High	High
	Low flows maintain water quality and instream habitat to: • increase native fish abundance including the threatened river blackfish. • maintain platypus, rakali and turtle populations • maintain the cover and condition of native instream and littoral vegetation. • maintain the diversity and abundance of macroinvertebrates.	Low flow – variable: year-round 400–1,000 ML/day	Every year whenever the volume is <400 ML/day, likely in below average, average, and wet climate scenarios	This low flow was delivered during the non-irrigation period each year between 2017–18 and 2019–20. This target has been extended to the full year and was met in 2020–21.	High	High, depending on IVT demand	High

Environmental assets	Target values	Indicative demand (for all sources of water in the system)		Watering history (from all sources of water)	2021–22		Implications for future demands
		Flow/volume	Required frequency (maximum dry interval)		Environmental demands for water (all sources)	Potential Commonwealth environmental water contribution?	Likely urgency of demand in 2022–23 if watering occurred as planned in 2021–22
Lower Broken Creek *Reach 4 Nathalia Weir to River Murray with en-route benefit to reach 1 (Boosey Creek to Nine Mile Creek), reach 2 (Nine Mile Creek) and reach 3 (Broken Creek confluence with Nine Mile Creek to Nathalia Weir).* • Native fish – Murray cod, golden perch, silver perch, unspecked hardyhead and Murray-Darling rainbow fish • Platypus, turtles, rakali • Vegetation – box-dominated grassy woodland communities, river swamp wallaby-grass • Birds – Australian Bittern • Environmental demand requires water in addition to irrigation supply • Source of return flows for use downstream in the River Murray.	Winter low flows to: • provide year-round habitat and instream refuge areas for native animals. • improve platypus carrying capacity and reduce predation risk. • minimise exposure of turtles during winter dormancy. • maintain longitudinal connectivity to allow instream fauna to access food and shelter. • maintain inundation of instream aquatic plants, so they persist and provide food and cover for native fauna. • reduce stagnation of water in weir pools.	Low flows: May to August 20 to 40 ML/day continuous	Every year under all climate scenarios	The minimum requirement and has been met or partially achieved since 2011–12.	High	High, depending on IVT demand	High
	Spring, summer; and autumn low flows to: • increase availability of instream habitat for native fauna. • increase flow cues for fish movement and spawning. • provide soil moisture to improve the establishment and growth of native littoral vegetation. • inundate benches to promote the growth of instream aquatic species. • increase mobilisation of *Azolla* accumulations. • reduce stagnation of water in weir pools.	Spring/summer/autumn low flows: Sept to May 200–250 ML/day continuous	Every year under all climate scenarios	Spring/summer/autumn low flows have been met or partially achieved since 2011–12 through a combination of environmental water and consumptive deliveries. In recent years, Inter-Valley Transfers and Murray Bypass flows have significantly contributed to the provision of these flows.	High	High, depending on IVT demand	High
	Winter/spring freshes will: • Flush and mobilise Azolla when it has accumulated Note: flows over 300 ML/d can flush *Azolla* whilst it is still in single layers or individual plants. Flushes up to 450 ML/d disperse large blooms • Trigger native fish movement and spawning • Encourage germination and growth of bank and in-stream vegetation	Winter/spring freshes: July to September 1 to 3 actions of 300–450 ML/day for 1 to 2 weeks	Every year under all climate scenarios	Freshes have been met in most years since 2011–12 and partially achieved in others. Environmental water deliveries have contributed significantly to the provision of spring freshes. A late winter/spring fresh through environmental water delivery was not required in 2019–20 as Azolla levels remained low.	Moderate - unless there is high Azolla presence	High - if there is high Azolla presence and depending on the volumes of IVT and operations water delivered from the Goulburn and Murray systems	Moderate - unless there is high Azolla presence

Environmental assets	Target values	Indicative demand (for all sources of water in the system)		Watering history (from all sources of water)	2021–22		Implications for future demands
		Flow/volume	Required frequency (maximum dry interval)		Environmental demands for water (all sources)	Potential Commonwealth environmental water contribution?	Likely urgency of demand in 2022–23 if watering occurred as planned in 2021–22
Goulburn-Broken catchment wetlands (Moodie Swamp) *Accessed via Gearys channel from reach 2; Waggarandall Weir to Reillys Weir* • Birds – Brolga and Australasian Bittern Native vegetation - cane grass and rigid water milfoil	Encourage flocking and breeding of Brolga and improve Cane Grass Wetland EVC and maintain rigid water milfoil population.	Fill Moodie Swamp to a variable depth of 0.5-1m for 6 -9 months - in autumn 2022 and top-up when required.	Moodie Swamp maximum dry interval is 1 year for waterbirds and 3 years for vegetation	Environmental water has been delivered to Moodie Swamp each year between 2013–14 and 2017–18. No water was required in 2018–19 and in 2019–20 natural flows partially filled the wetland.	High	High	Low
Upper Broken Creek *Reach 1 Casey's Weir to Waggarandall Weir* • Native fish – Murray cod, golden perch, Murray-Darling rainbow fish • Vegetation – instream vegetation, box riparian vegetation, remnant plains grassy woodland, buloke trees and rigid water milfoil (Moonie Swamp) • Platypus • Common long-necked turtle • Birds – brolga, Australasian bittern (Moonie Swamp)	These low flows are to maintain: • habitat for native fish, water bugs and platypus • water quality and oxygen levels for native fish, platypus and waterbugs	Low flows: winter 1–10 ML/day Low flows: spring 1–10 ML/day Low flows: summer 1–5 ML/day Low flows: autumn 1–5 ML/day	All year round under all scenarios	Lowflows of 5 ML/day were not met in 2011–12, 2013–14 and 2019–20 and were partially met in other years including 2020–21. Lowflows of 10 ML/day have been partially met 2014–15 and 2017–18 and not met in other years since 2010–11, including in 2020–21.	High	High, depending on IVT demand	High
	This fresh is to flush pools to improve water quality and to increase dissolved oxygen levels	Fresh: Dec to May 1 action of 50–100 ML/day for 10 days	One delivery per year under all climate scenarios	This is the first time this flow action has been planned	High	High, depending on IVT demand	High
Broken River • Native fish - Murray cod, golden perch, silver perch, Murray-Darling rainbow fish, Macquarie perch, river black fish and mountain galaxias • Vegetation – riparian and instream vegetation including eel grass, common reed and water ribbon	Low flows in all reaches to maintain: • riffles, slackwater and pool habitats for native fish, plants, platypus and waterbugs • water quality and oxygen levels to support native animals • instream and fringing vegetation	Low flows: all year 15–30 ML/day	Under extremely dry and dry climate scenarios	Natural flows, consumptive water and banked flows have met/partially met this flow target since 2010–11	High if not met by operational releases (consumptive water and IVT) or natural flows	High if not met by operational releases (consumptive water and IVT) or natural flows	High if not met by operational releases (consumptive water and IVT) or natural flows
	Summer/autumn fresh in Reach 1 to: • turn over bed sediments • scour around large wood • provide flow cues to stimulate native fish breeding and movements • promote biofilm productivity	Fresh – summer/autumn 1 action of 400–500 ML/day for 2 to 5 days	Under dry and average climate scenarios	This target was met in 4 years between 2010–11 and 2019–20. It was achieved in 2020–21.	High if not met by operational releases (consumptive water and IVT) or natural flows	High if not met by operational releases (consumptive water and IVT) or natural flows	High if not met by operational releases (consumptive water and IVT) or natural flows

Environmental assets	Target values	Indicative demand (for all sources of water in the system)		Watering history (from all sources of water)	2021–22		Implications for future demands
		Flow/volume	Required frequency (maximum dry interval)		Environmental demands for water (all sources)	Potential Commonwealth environmental water contribution?	Likely urgency of demand in 2022–23 if watering occurred as planned in 2021–22
	• provide habitat for native fish passage						
Ovens River *Reach 1 immediately below Lake Buffalo on the Buffalo River; reach 2 immediately below Lake William Hovell on the King River; reach 3 Mohyu to the Ovens River; reach 4 Ovens River from the confluence of the Buffalo River to the confluence of the King River; reach 5 Ovens River downstream of the confluence of the King River to the Murray River; and Mullinmur wetland downstream of Wangaratta.* • Native fish – Murray cod, trout cod, golden perch, Macquarie perch and eel tailed catfish • Frogs – giant bullfrog and growling grass frog • Waterbirds – egrets, herons, cormorants and bitterns • Vegetation – river red gum forests and woodlands	Summer/autumn low flows to: • increase pool connectivity to encourage fish movement • provide small variation in river level to move sediment and maintain waterbug habitat • ensure sufficient dissolved oxygen levels	Low flow fresh below Lake Buffalo – March/April at the end of the irrigation season	Under an average climate scenario if a bulk release is being delivered	In 2011–12 to 2013–14 and 2016–17, 2019–20 and 2020–21 CEW was delivered as part of a bulk release by GMW.	High – delivered each year	High	High – delivered each year
		Low flow contribution below Lake Buffalo – February to March	Under a dry to average climate scenario if a low flow fresh is not delivered as part of a bulk release	In 2014–15, 2015–16, 2017–18 and 2018–19 CEW this flow action was met.	High – delivered each year	High	High – delivered each year
		Low flow contribution below Lake Willian Hovell – February to March	Under a dry to average climate scenario	This flow action has been met since 2021–13, including in 2020–21	High – delivered each year	High	High – delivered each year
Mullinmur wetland • *Is located on the Lower Ovens River floodplain within Wangaratta.* • Native fish - catfish and southern pygmy perch • Vegetation – river red gum, herbland species, gold-dust wattle and common swamp wallaby-grass	To maintain water level to support aquatic vegetation and habitat for native eel-tailed catfish and other native fish.	Top up when required	Likely under a dry to average scenario.	This action was included in the planning for the first time. In 2019–20 when 20 ML was delivered to support the translocation of native eel-tailed catfish. Natural inflows filled the wetland during 2020–21 and no environmental water was required.	High – if not filled by natural flows	High, if needed	High – if not filled by natural flows
Campaspe	A winter low flow will:	Winter/spring low flow (50- 200 ML/day during June to November)	For 180 days in all climatic scenarios (may be met naturally in wet scenario, delivered	This flow component has been delivered every year since 2012–13.	High	May be met by other means	High

Environmental assets	Target values	Indicative demand (for all sources of water in the system)		Watering history (from all sources of water)	2021–22		Implications for future demands
		Flow/volume	Required frequency (maximum dry interval)		Environmental demands for water (all sources)	Potential Commonwealth environmental water contribution?	Likely urgency of demand in 2022–23 if watering occurred as planned in 2021–22
Reach 2 Eppalock to Campaspe Weir; reach 3 Campaspe Weir to Campaspe Siphon at Rochester; and reach 4 Campaspe Siphon to River Murray • Native fish - Murray cod, silver perch, golden perch, Murray-Darling rainbow fish and flat headed gudgeon • Platypus, rakali, turtles and frogs • Bank and instream vegetation, especially mature river red gum trees that support terrestrial fauna, including the swift parrot and squirrel glider. During the past four years very high volumes of intervalley transfer water has impacted on the planned delivery of environmental water and this may continue during 2021–22 unless wetter conditions persist.	• Maintain water quality, preventing pools from stratifying • Increase connectivity to allow native fish to access new habitats • Facilitate male platypus long-distance movement, especially in the August–October breeding season • Provide female platypus foraging opportunities before breeding • Discourage terrestrial plants colonising the lower riverbank/channel benches • Maintain soil moisture in the riverbank, water established river red gums and woody shrubs • Help establish littoral vegetation.		at increased magnitude in moderate-wet scenarios, may not be delivered in drought scenario)	Environmental water releases, natural flows and IVT maintained winter low flows for vegetation, longitudinal connectivity for native fish, macroinvertebrates and water quality in 2020–21. During dry conditions this flow has been delivered at the lower end of the flow ranges.			
	The winter freshes aim to: • Flush accumulated leaf litter from banks/low benches to reduce risk of blackwater events during high river flow in summer • Maintain soil moisture for established river red gum/ woody shrubs • Maintain connectivity to allow native fish movement/access to new habitats, especially during Murray cod nesting period • Encourage platypus to nest higher up the bank, reducing risk of high flows flooding burrows with juveniles.	Winter/spring freshes (two freshes of approximately 1,000- 1,600 ML/day for two to three days during June to November)	Two deliveries per year under dry and wet scenarios, one delivery in a moderate scenario	This flow component has been delivered every year since 2012–13. Environmental water releases and IVT provided winter high flows for native fish and macroinvertebrate populations and native vegetation in 2020–21. High flow mitigated the risk of Blackwater events during summer from natural or managed high flow events. During dry conditions this flow has been delivered at the lower end of the flow ranges.	Moderate	High	Moderate
	A summer low flow will: • Maintain slackwater habitats for zooplankton and nursery habitats for native fish • Maintain water depth, preventing stratification in deep pools, to maintain habitat for native fish and platypus, allowing safe movement between pools while foraging.	Summer/autumn low flow (maintained at 40-50ML/day during December to May, will only drop below this in drought scenarios)	For 180 days under all climate scenarios (high magnitude range for mod-wet scenarios, low magnitude range for dry scenarios)	This flow component has been delivered every year since 2012–13. Since 2017–18, annual intervalley transfers have exceeded the recommended summer low flows and freshes. In 2020–21, Inter-valley trade deliveries and irrigation resulted in higher then recommended summer low flow.	High	May be met by other means	High
	The summer freshes aim to:	Summer/autumn freshes (three freshes of 50-	Three deliveries per year under all climate scenarios	Environmental water releases in addition to base IVT deliveries	Moderate	May be met by other means	Moderate

Environmental assets	Target values	Indicative demand (for all sources of water in the system)		Watering history (from all sources of water)	2021–22		Implications for future demands
		Flow/volume	**Required frequency (maximum dry interval)**		**Environmental demands for water (all sources)**	**Potential Commonwealth environmental water contribution?**	**Likely urgency of demand in 2022–23 if watering occurred as planned in 2021–22**
	• Increase connectivity to allow native fish to access new habitats • Promote new biofilm growth and increase waterbug productivity for native fish and platypus • Facilitate downstream dispersal of juvenile platypus to colonise other habitats (April-May).	200 ML/day for one to three days during February to April)		provided one summer fresh in January 2020. Since 2017–18, annual intervalley transfers have exceeded the recommended summer low flows and freshes.			
	If triggered, the year-round fresh aims to de-stratify pools and improve water quality (increase oxygen levels) along the river in reach 4, ensuring adequate oxygen to support aquatic animals.	Year-round fresh (trigger- based, 5-200 ML/day, as required) Triggers • oxygen levels are below 5 mg/L • air temperatures are above 28° • there are high water temperatures and/or low river flow	As required based on trigger	Freshes have been delivered every year since 2012–13, the year-round fresh is a new action intended to support aquatic animals in critical scenarios.	High	High	Moderate
	Loddon *Reach 4 Loddon Weir to Kerang Weir with en route benefit to reaches 1 to 3 storage reservoirs to Loddon Weir and to reach 5 downstream Kerang Weir.* • Native fish - river blackfish, Murray-Darling rainbow fish and golden perch • Vegetation – cane grass, tangled lignum, black box and river red gum	A winter low flow will: • Increase water depth for fish, platypus and rakali dispersal (juvenile male platypus can colonise new winter breeding territory), providing foraging habitat • Prevent silt/fine sediment settling on hard surfaces • Inundate habitats to increase biofilms and support waterbug productivity • Water native fringing bank vegetation, to support seed germination/growth and	Winter/spring low flow (50- 100 ML/day during June to November)	Delivered in all scenarios (at a passing flow rate in dry-average scenarios, delivered at lower magnitude in a drought scenario. In a supply deficit, delivered at higher magnitude in dry and average scenarios)	The winter low flow has been delivered in every year since 2012–13 except for 2016–17 when it was partially achieved due to natural flooding causing water to be delivered at a higher rate and longer duration.	Moderate	May be met by other means	High

Environmental assets	Target values	Indicative demand (for all sources of water in the system)		Watering history (from all sources of water)	2021–22		Implications for future demands
		Flow/volume	Required frequency (maximum dry interval)		Environmental demands for water (all sources)	Potential Commonwealth environmental water contribution?	Likely urgency of demand in 2022–23 if watering occurred as planned in 2021–22
• Platypus • Rakali	prevent encroachment of exotic terrestrial plants.						
	A winter high flow will: • Scour biofilms and accumulated sediment from pools • Flush accumulated organic matter from bank/benches, to increase productivity and reduce the risk of a summer hypoxic blackwater event • Wet banks to promote the recruitment/growth of streamside and emergent vegetation • Stimulate native fish movement and breeding.	Winter/spring high flow (one high flow of 450 ML/day for six to 10 days during August to November)	Delivered in all climate scenarios (at lower duration for drought-dry scenarios)	A winter fresh was partially delivered in 2013–14, 2014–15 and 2015–16, and fully delivered in 2012–13 and since 2016–17.	High	High	Moderate
	A summer low flow will: • Maintain adequate depth in pools for aquatic plants and provide habitat for waterbugs, fish and rakali • Maintain water quality, by continuous flow through the reach, • Wet banks/shallow riffles, supporting growth of in-stream and fringing non-woody vegetation	Summer/autumn low flow (25-50 ML/day during December to May)	Delivered in all climate scenarios (at lower magnitude for drought-dry scenarios. In a supply deficit, delivered at higher magnitude in a dry scenarios)	The summer low flows have been delivered in every year since 2012–13 in reach 4.	High	May be met by other means	High
	The summer freshes aim to: • Increase water level, promoting seed germination/growth of fringing emergent macrophytes • Increase connectivity between deep pools, prompting the local movement of fish and dispersal of juvenile platypus in autumn • Flush fine sediment and old biofilms from submerged hard surfaces, promoting growth of new biofilms and increasing waterbug productivity • Freshen water quality and reoxygenate pools.	Summer/autumn freshes (three to four freshes of 50-100 ML/day for three days during December to May)	Delivered in all climate scenarios (with potential additional fresh in drought scenario).	The summer freshes have been delivered in every year since 2012–13, except in 2018–19 when it was partially achieved.	Low	High	High

Environmental assets	Target values	Indicative demand (for all sources of water in the system)		Watering history (from all sources of water)	2021–22		Implications for future demands
		Flow/volume	Required frequency (maximum dry interval)		Environmental demands for water (all sources)	Potential Commonwealth environmental water contribution?	Likely urgency of demand in 2022–23 if watering occurred as planned in 2021–22
	The autumn high flow will: • Trigger and facilitate upstream movement of golden perch, silver perch and Murray cod older than 1 year • Facilitate dispersal of juvenile platypus • Flush fine sediment/old biofilms from submerged hard surfaces, promoting growth of new biofilms and increasing waterbug productivity.	Autumn high flow (one high flow of 400 ML/day for six days during March to May)	Delivered in wet scenario only, or in average scenarios with a supply deficit.	The autumn high flow has only been achieved in 2016–17. It was not delivered in 2020–21.	High	May be met by other means	Moderate
Serpentine *Reach 1 is the priority reach in the Serpentine Creek system.*	A winter low flow will: • 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 diversity of fringing vegetation • Provide sufficient water depth and flow variability to maintain microbial biofilms.	Winter/spring low flow (20- 50 ML/day during June to November)	Annually in all climate scenarios	This flow was partially delivered in 2017–18 and 2020–21, and not achieved in 2018–19 or 2019–20.	High	Met by other means	Moderate
	The winter fresh aims to: • Maintain the channel form and scour pools[a] • Provide connectivity for fish and waterbugs to access different habitat, supporting a diversity of functional feeding groups • Transport accumulated organic matter in the channel, to increase decay in winter/spring and reduce risk of a summer hypoxic blackwater event* • Encourage platypus to nest higher up the bank (when delivered at 120-150 ML/day), reducing risk of high flows flooding burrows with juveniles.	Winter/spring fresh (one fresh of 40-150 ML/days for two days during August to November)	Delivered in all climate scenarios (at lower magnitude for drought-dry scenarios)	This fresh has been delivered every year since 2017–18.	Moderate	High	Moderate

Environmental assets	Target values	Indicative demand (for all sources of water in the system)		Watering history (from all sources of water)	2021–22		Implications for future demands
		Flow/volume	**Required frequency (maximum dry interval)**		**Environmental demands for water (all sources)**	**Potential Commonwealth environmental water contribution?**	**Likely urgency of demand in 2022–23 if watering occurred as planned in 2021–22**
	A summer low flow will: • Provide connectivity between pools to allow dispersal of native fish • Wet exposed roots, leaf packs and woody debris, to provide habitat for aquatic animals • Maintain water quality by oxygenating pools • Maintain foraging habitat for platypus • Maintain wetted area to support in-stream aquatic vegetation.	Summer/autumn low flow (10-20 ML/day during December to May)	Annually in all climate scenarios	This flow was not delivered in 2017–18 and 2018–19; it was fully delivered in 2019–20 and 2020–21.	High		High
	The summer freshes aim to: • Maintain channel form by inundating benches • Flush fine sediment/old biofilms from hard surfaces, increasing productivity and replenishing food supply for aquatic animals • Transport accumulated organic matter in the channel, providing carbon and nutrients downstream • Provide flow variability to maintain diversity of fringing vegetation • Freshen water quality by diluting salt and re-oxygenate pools.	Summer/autumn freshes (three freshes of 40 ML/ day for two days during December to May)	Up to three freshes in all climate scenarios	These freshes were partially delivered in 2017–18 and 2018–19 and fully delivered in 2019–20. They were not delivered in 2020–21.	High		Moderate
Wimmera system	To support native riparian vegetation, native fish and waterbugs, and improve connectivity and water quality.	Up to the total Commonwealth entitlement of 28 000 ML (low reliability water share) per year to contribute toward instream flows within the Wimmera River (lowflow and freshes)	Annually	In 2016–17 the Commonwealth received its first and only allocation of 14,280 ML against this entitlement. Through careful management and carryover this water was progressively used (alongside VEWH water) throughout 2017 to early 2020 to support lowflows in the Wimmera system.	Critical	Low. The Commonwealth has no allocations or carryover currently available in the Wimmera. It will take significant inflows under a wet or very wet scenario before water becomes available to use.	Critical

Note: The planned flow actions outlined in this table are consistent with the potential environmental watering actions presented in the Catchment Management Authorities 2021–22 Seasonal Watering Proposals and the Victorian Environmental Water Holder *Seasonal Watering Plan 2021-22*. Demand is considered at a generalised scale, there may be specific requirements that are more or less urgent within the flow regime. a) Augmented response expected when delivered at 120-150 ML/day.

Key

Potential watering in 2021–22

- High priority for Commonwealth environmental watering (likely to receive water even under low water availability)
- Secondary priority for Commonwealth environmental watering (watering to occur only if natural trigger is met, or under moderate – high water resource availability); or water demand likely to be met via other means
- Low priority for Commonwealth environmental watering (under high – very high water resource availability); or unable to provide water because of constraints or insufficient water

Environmental demands (demand is considered at a generalised scale; there may be specific requirements that are more or less urgent within the flow regime)

- High to critical demand for water (needed in that particular year or urgent in that particular year to manage risk of irretrievable loss or damage)

Moderate demand for water (water needed in that particular year, the next year, or both)

Low demand for water (water generally not needed in that particular year)

13.5 Water delivery in 2021–22

Consistent with the demands and purpose identified in Table VR3, and as water for the environment becomes available, the CEWO is considering supplying water for the environment to contribute to:

- low flows and freshes in each river, as well as off channel wetland actions that support a range of environmental outcomes for plants and animals
- flows that are coordinated across the Southern-connected Basin when conditions are conducive to achieve identified ecological outcomes, for example, golden and silver perch migration
- enhancing ecological benefit from natural flows and when possible, intervalley transfer flows, for example, adding water to the peak or during the recession of the flow – these recession flows can help reduce bank slumping (by avoiding rapid drops in water levels) and can help reduce the impacts of adverse water quality events (e.g. low oxygen blackwater events).

The use of Commonwealth water will be consistent with and contribute to the objectives and actions identified in the Victorian Seasonal Watering Plan.

As in previous years, the use of Commonwealth, Victorian and The Living Murray water will be adaptively managed together throughout 2021–22, in response to changing water resource availability and environmental conditions and demands.

13.6 Monitoring and lessons learned

13.6.1 Monitoring

Monitoring in the Goulburn is now in its eighth year encompassing the CEWO-funded Monitoring, Evaluation and Research (MER) program from 2019–20 to 2021–22 and the Long Term Intervention Monitoring Project (LTIM) from 2014–15 to 2018–19. This work complements the Victorian Environmental Flow Monitoring Assessment Program (VEFMAP), which examines the effect of water for the environment along 13 Victorian Rivers.

13.6.2 Lessons learned

Outcomes from monitoring and lessons learned in previous years are a critical component for the effective and efficient use of Commonwealth water for the environment. These learnings are incorporated into the way environmental water is managed.

Key findings from the MER (CEWO 2020) and VEFMAP (VEFMAP 2021) projects are summarised in Table VR4.

Table VR4 Key lessons learned in the Victorian Rivers

Theme	Outcomes and lesson learned
Native fish	*Goulburn River* • Species of conservation significance collected were Murray cod, trout cod, silver perch and Murray River rainbowfish. • Abundance of Murray cod increased in the 2020 surveys, following a decrease in abundance in 2017 after a blackwater event. • Silver perch abundance also increased in 2020, likely due to fish immigrating into the Goulburn River from the Murray River. • There was a marginal increase in abundance of Murray River rainbowfish in 2020, following a decrease in abundance from 2017 to 2019. • Two native (bony bream, flat-headed gudgeon) and two exotic (eastern gambusia, redfin perch) species collected in low numbers in previous surveys were not detected in 2020. • A fresh delivered in December 2020 resulted in the spawning of large numbers of golden perch and silver perch. *Campaspe* • Murray River rainbow fish, previously thought lost to the Campaspe system, observed at many sites and in abundance downstream of Elmore in reach 2. • Good numbers of Murray cod young-of-year. This may be a result of the 2019 winter high flow event, or reduced impact of intervalley transfers, due to smaller magnitude compared to previous years. *Loddon* • Combined Pyramid-Loddon spring fresh enhanced fish movement and populations in the Loddon River and Pyramid Creek. *Wimmera* • Fish monitoring in autumn 2018 showed that populations of small-bodied native fish have been maintained in all reaches of the Wimmera catchment that received environmental flows. *Lower Broken Creek* • The delivery of minimum low flows during the off-irrigation season provided refuge areas over winter, especially important for young-of-year fish. • Apart from during times when maintenance was being undertaken, fish ladders remained open providing fish connectivity throughout the system. • Freshes provided in spring encouraged native fish movement and spawning.
Macroinvertebrates	*Goulburn River* • The largest increase in the total number of macroinvertebrates (e.g. shrimps, water bugs, mayflies and caddisflies) happens from January onwards. However, it is not yet known the extent that this is attributed to seasonal increases in temperature and hours of daylight versus flow actions. Some increase also followed the spring fresh.
Stream metabolism	*Goulburn River* • Summer flows produced the most organic carbon (80 tonnes) followed by flows in spring (77 tonnes) winter (36 tonnes), and autumn (32 tonnes). • The total amount of organic carbon produced increases even with small increases in flow volume. • Increased in-channel flows increases the amount of organic carbon produced within the river channel which is an important food resource for macroinvertebrates and fish.
Vegetation	*Goulburn River* • Water dependant plants generally increased in cover after the spring freshes across the bank elevation influenced by the fresh. Grasses were restricted to higher bank elevations where inundation was shallower and for shorter duration.

Theme	Outcomes and lesson learned
	• IVT contributed to the absence/loss of vegetation on the banks and a narrowing of the band of water dependant plants. Modelling indicates that vegetation on the banks steadily declines if the total duration of IVT flows exceeds 55 days. • During winter and spring freshes submerged river and bank features received flow-delivered sediment and seeds. More sediment was deposited on low-level features such as bars and more seeds were deposited on both bars and higher-level features such as benches. *Lower Broken Creek* • The minimum low flows over winter retained water in the main creek channel inundating instream aquatic plants. • High and prolonged flows during winter and spring flushed accumulated Azolla and kept levels very low for the remainder of the year. • The spring freshes provided soil moisture for developing plants on the lower banks and benches.
Bank condition	*Goulburn River* • Moderate erosion (more than all other flow events) occurred primarily within bank zones corresponding to IVT flows between 1,500-3,000 ML/d. Minor notching occurred on some inside banks. No evidence of mass-failure was observed (in contrast to 2018–19 IVT delivery), so pulsing may have had a positive impact minimising excessive erosion and mass-failure. • Recession flows following natural freshes resulted in the largest volume of deposition and the second largest volume of erosion during 2019–20. Deposition was likely a result of increased % contribution of tributary flows to natural fresh events. Increased levels of erosion were largely a result of the events mimicking the shape of the earlier IVT flow, which appears to have prepared banks for increased erosion by surcharging upper banks. • Low-medium erosion and deposition occurred across lower and upper bank zones within the zone of bank inundated by the fresh at >3000 ML/d.

References

BOM 2021a, Climate outlooks: rainfall – the chance of above median for July to September 2021, Bureau of Meteorology, Canberra, accessed 15 June 2021.

——2021b, Climate outlooks: temperature – the chance of above median maximum temperatures for July to September 2021, Bureau of Meteorology, Canberra, accessed 15 June 2021.

CEWO 2020, Goulburn MER Annual Reports 2019-20, Commonwealth of Australia, Canberra, 2020.

DEWLP 2019, Overview: Murray-Darling Basin, Department of Water, Land and Planning, Melbourne, Victoria, accessed 15 June 2021.

GBCMA 2021a, Goulburn River Seasonal Watering Proposal 2021-22, Goulburn-Broken Catchment Management Authority, Shepparton, Victoria, accessed 15 June 2021.

——2021b, Lower Broken Creek Seasonal Watering Proposal 2020-21, Goulburn-Broken Catchment Management Authority, Shepparton, Victoria, accessed 15 June 2021.

——2021c, Broken River System Seasonal Watering Proposal 2021-22, Goulburn-Broken Catchment Management Authority, Shepparton, Victoria, accessed 19 July 2021.

——2021d, Broken Wetlands Seasonal Watering Proposal 2020-21, Goulburn-Broken Catchment Management Authority, Shepparton, Victoria, accessed 19 July 2021.

GMW 2021, Lake Eildon, Goulburn-Murray Water, Tatura, Victoria, accessed 19 July 2021.

NCCMA 2021a, *Seasonal Watering Proposal Campaspe River Downstream of Lake Eppalock 2021–22 (draft)*, North Central Catchment Management Authority, Huntly, Victoria, 2021.

——2021b, *Seasonal Watering Proposal Loddon River System 2021–21 (draft),* North Central Catchment Management Authority, Huntly, Victoria, 2021.

NECMA 2021, *2021–22 Ovens River System Seasonal Watering Proposal*, North East Catchment Management Authority, Wodonga, Victoria, 2021.

VEFMAP 2021, Assessing Benefits of Watering for the Environment, Arthur Rylah Institute for Environmental Research, Department of Environment, Land, Water and Planning, Melbourne, Victoria, accessed 14 June 2021.

WCMA 2021, *Seasonal Watering Proposal for the Wimmera River System 2020–21,* Wimmera Catchment Management Authority, Victoria, 2021.

MDBA 2019, Basin-wide environmental watering strategy, Murray Darling Basin Authority, Canberra, accessed 30 June 2021.

——2021, Water management: catchments, Murray Darling Basin Authority, Canberra, accessed 30 June 2021.

VEWH 2021, Victorian Environmental Water Holder Seasonal Watering Plan 2021-22, Melbourne, Victoria, accessed 15 June 2021.