



Australian Government

Commonwealth Environmental Water Office

Commonwealth Environmental Water Office Water Management Plan 2021–22

Chapter 12 Murrumbidgee River 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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12 Murrumbidgee River Valley Water Plan

12.1 Region overview

12.1.1 River system

The Murrumbidgee River Valley (Map MR1) covers 84 000 square kilometres of southern New South Wales. It is bordered by the Great Dividing Range to the east, the Lachlan River Valley to the north and the River Murray Valley to the south (Green et al. 2011). The river originates in the alpine area of Kosciuszko National Park and flows through the Monaro High Plains and the low-lying plains of the western Riverina, joining the River Murray south of Balranald.

Most of the flow in the Murrumbidgee River comes from the upper portion of the catchment (gaining stream) and is delivered by the main tributary rivers: Cotter, Yass, Molonglo, Queanbeyan, Bredbo, Numeralla, Goodradigbee and Tumut (Kingsford and Thomas 2001). Several tributaries located immediately downstream of the dams contribute significant inflows, including Adelong, Adjungbilly, Gilmore, Hillas, Tarcutta, Kyeamba, Jugiong, Muttama, Billabong and Houlaghans Creeks, and Goobarrandra River (SKM 2011). The middle and lower portions of the catchment do not contribute significant inflows (losing stream).

The Yanco, Billabong, Colombo and Forest Creek network (known as the Yanco Creek System) is an anabranch complex that broadly connects the Murrumbidgee River with the Edward River. Water can be diverted from the Murrumbidgee River into the Yanco Creek at the Yanco Weir. Unregulated flows from Billabong Creek enter the regulated system east of Jerilderie, in addition to regulated inlets via Coleambally Irrigation Co Ltd and Murray Irrigation Ltd drainage systems.

Regulated water is provided by two major headwater storages, Burrinjuck Dam on the Murrumbidgee River and Blowering Dam on the Tumut River. Collectively these storages have a capacity of 2654 gigalitres. Blowering Dam and Tantangara Reservoir catchments are also affected by the operation of the Snowy Mountains Hydro Electricity scheme.

12.1.2 Traditional Owners

The rivers and wetlands of the Murrumbidgee River Valley hold significant spiritual and cultural importance for Aboriginal people. The Wiradjuri are the largest Aboriginal nation in the Murrumbidgee River valley, with their nation extending from the River Murray in the south to beyond Dubbo in the north, and west to Balranald. At the western end of the catchment are the traditional land of the Barapa Barapa, Muthi Muthi, Nari Nari, Nyeri Nyeri, Wadi Wadi, Wamba Wamba, Weki Weki, and Wolgalu nations. The mountains at the eastern end of the Murrumbidgee River Valley are the country of the Ngunawal and Ngarigo nations. (MDBA 2021). 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.

12.1.3 Important sites and values

Supporting a complex range of natural ecosystems, the Murrumbidgee River Valley contains many significant in-channel and wetland habitats which provide important habitat for a range of aquatic and terrestrial species including frogs, fish and waterbirds.

Commonwealth water for the environment is delivered to several important regions in the Murrumbidgee River Valley, including but not limited to the mid-Murrumbidgee wetlands, Yanco Creek system, Lowbidgee floodplain and Murrumbidgee River. These regions provide critical habitat for a range of water dependent animals, including internationally listed migratory waterbirds and a range of

threatened species including the southern bell frog, Australasian bittern, trout cod, Murray cod, silver perch, native catfish, fishing bat; and freckled and blue-billed ducks.

Murrumbidgee River

The Murrumbidgee River spans approximately 1600 km (Frazier et al. 2005) and is heavily regulated with 26 dams, weirs and irrigation channels (SKM 2011). The lowland section of River between Gundagai and Balranald consist of meandering channels and wide floodplains, providing a range of aquatic habitats (Green et al. 2011) which play a critical role in the life cycles of a variety of species (MDBA 2012).

River regulation has affected the frequency and duration of floodplain inundation, with the magnitude of small to medium floods on the Murrumbidgee River having significantly reduced (Frazier et al. 1995). This has had a significant impact on the river and the plants and animals that depend on it. It has also altered the natural seasonal flow patterns, with higher flows now occurring in summer and early autumn to meet irrigation demand and lower flows occurring during winter and spring when inflows are captured in the dam (CSIRO 2008, Frazier et al. 2005). River regulation has significantly contributed to native fish declines in the Murrumbidgee, with the native riverine fish communities remaining in poor condition (Wassens et al. 2020a). Davies et al. 2008, as part of the Sustainable Rivers Audit, found the overall condition and ecosystem health of the Murrumbidgee Valley to be very poor.

Mid-Murrumbidgee Wetlands

The mid-Murrumbidgee wetlands are located on the Murrumbidgee River floodplain between Wagga Wagga and Carrathool and consist of hundreds of lagoons and billabongs (MDBA 2012a), with several listed as nationally significant in the Directory of Important Wetlands of Australia (EA 2001). The mid-Murrumbidgee wetlands are also part of the Natural Drainage System of the Lower Murray River Management Catchment aquatic endangered ecological community listed under the NSW *Fisheries Management Act 1994*.

The mid-Murrumbidgee wetlands system is characterised by river red gum forests with marginal black box woodlands, and open water habitat of permanent to semi-permanent wetlands with aquatic plants such as lignum, garland lily and spike rush (NSW DPIE 2020a, MDBA 2012a, CSIRO 2008). Many of these wetlands rely on higher flows in the Murrumbidgee River to fill (Murray 2008). However, due to river regulation, inundation frequency and duration has significantly reduced, resulting in the overall poor condition of the mid-Murrumbidgee wetlands. Whilst the use of pumping infrastructure to deliver water for the environment has helped to improve or maintain the condition of a small number of wetlands in the mid-Murrumbidgee, it is not as ecologically effective as filling wetlands with a reconnecting river flow. As such, a high priority for environmental watering is reconnecting these wetlands to help the recovery of aquatic vegetation and improve the health of the river by enabling nutrients and animals to flow to and from the river.

Murrumbidgee Irrigation Area wetlands

Several significant wetlands occur in the Murrumbidgee Irrigation Area and require the use of irrigation infrastructure to receive environmental water. This includes Fivebough and Tuckerbil Swamps which are listed as wetlands of international importance under the Ramsar Convention. Both wetlands support a high abundance and diversity of waterbirds, including migratory waterbirds listed under international agreements (JAMBA, ROKAMBA, CAMBA, Bonn Convention) and threatened species, including the endangered Australasian bittern and Australian painted snipe (EPBC Act). They also provide significant breeding habitat for waterbirds including egrets and broilgas (White 2011).

Yanco Creek System

The Yanco Creek system consists of four major creeks: the Yanco, Billabong, Colombo, and Forest Creeks; and receives the majority of inflows from the Murrumbidgee River supplemented by catchment inflows from the unregulated Billabong Creek. The system discharges into the Edward River which is an anabranch of the River Murray (Alluvium 2013). This system is known to provide important native fish habitat, including for the threatened trout cod and freshwater (eel-tailed) catfish (Alluvium 2013). Floodplain wetlands occur throughout the Yanco Creek system providing important habitat for a range of species. This includes Wanganella Swamp which is a significant waterbird breeding site located in the Forest Creek system.

Lower Murrumbidgee (Lowbidgee) Floodplain

The Lowbidgee floodplain is located between Maude and Balranald and is listed on the Directory of Important Wetlands in Australia (EA 2001) and forms part of the Natural Drainage System of the Lower Murray River Catchment aquatic endangered ecological community, listed under the *NSW Fisheries Management Act 1994*. The Lowbidgee floodplain contains the third largest river red gum forest in Australia (Murrumbidgee CMA 2009), some of the largest lignum wetlands in New South Wales (CSIRO 2008) and has significant black box and reed bed communities (Murrumbidgee CMA 2009). Some of the Murray-Darling Basin's largest breeding sites for colonial nesting waterbirds and migratory waterbird species listed under bilateral agreements occur on the Lowbidgee floodplain (Wassens et al. 2019a).

The Lowbidgee floodplain can be inundated through controlled diversions from Maude and Redbank weirs or via overbank flooding from the river. The Lowbidgee floodplain can be divided into three wetland systems based on distinctive hydrological and ecological characteristics and are Gayini Nimmie-Caira, Fiddlers-Uara and Redbank systems. Gayini Nimmie-Caira supports extensive areas of lignum shrubland that provides important waterbird breeding habitat and important habitat for the threatened southern bell frog. Fiddlers-Uara creeks are the most upstream major distributaries on the Lowbidgee and support black box woodlands with lignum, nitre goosefoot and river cooba understory (MDBA 2012b, SKM 2011, NSW DPIE 2020a). The Redbank system consists of North and South (Yanga National Park) Redbank and is dominated by river red gum forests and woodlands with marginal black box woodlands (CSIRO 2008), and a high proportion of open water and semi-permanent wetland communities, including aquatic herbs and spike rush sedgeland (MDBA 2012b, NSW DPIE 2020a). This area also provides important waterbird breeding habitat.

At the western edge of the Lowbidgee is the Western Lakes, which is a complex of ephemeral lakes, wetlands and connecting waterways. The Western Lakes were disconnected from the Murrumbidgee River in the early 1900's due to the construction of diversion structures on the floodplain (Kingsford and Thomas 2001, NSW OEH 2012) and remained isolated until flow diversion works enabled the delivery of water for the environment in 2011 (NSW OEH 2012). This area provides habitat for a diverse range of waterbirds.

Junction Wetlands

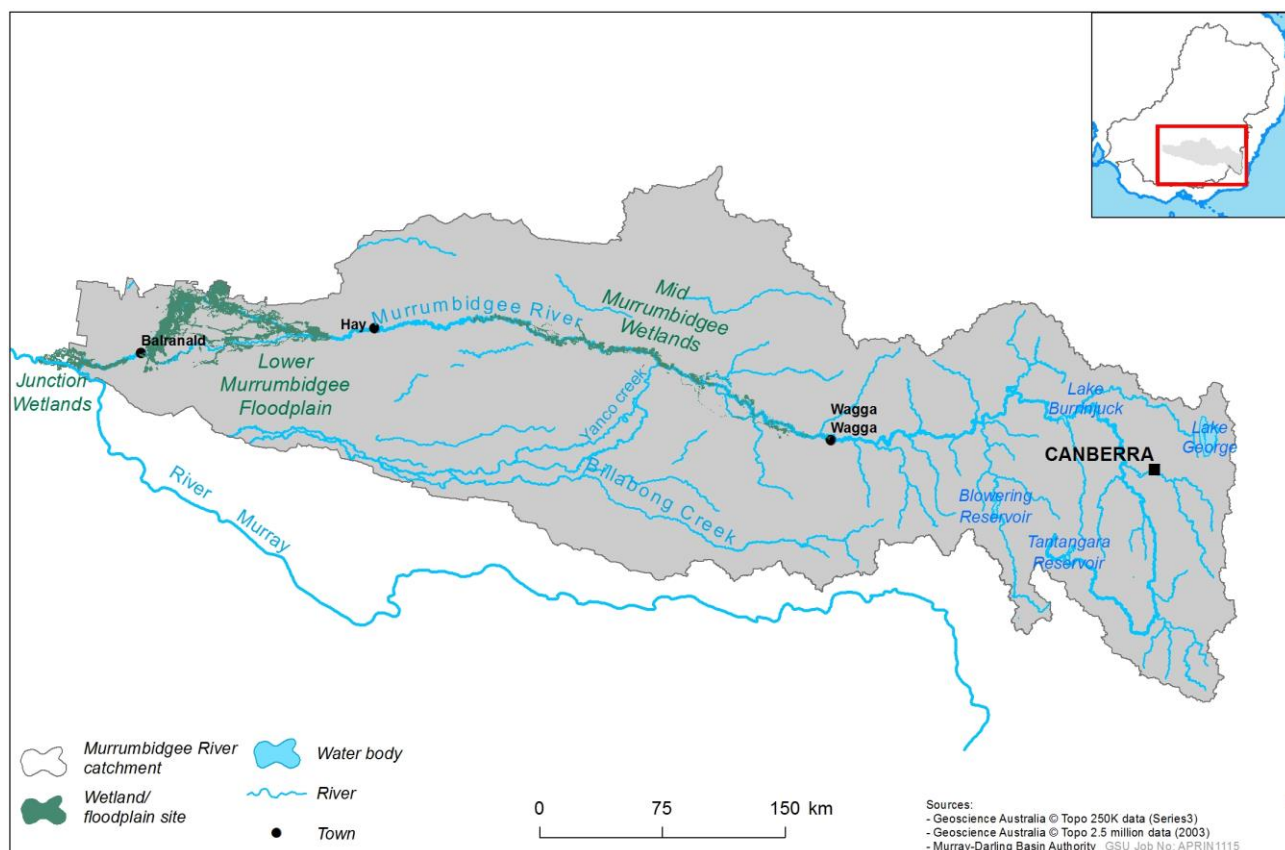
The Junction Wetlands lie between Balranald and the confluence of the Murrumbidgee and Murray Rivers. This area consists of several creeks, lagoons, and areas of river red gum forest, black box, and mallee (SKM 2011).

12.1.4 Stakeholder engagement

In the Murrumbidgee River Valley, the planning, management and delivery of Commonwealth water for the environment is undertaken in conjunction with a range of partners and stakeholder groups. Key stakeholders include the New South Wales Department of Planning, Industry and Environment (DPIE) – Biodiversity and Conservation, NSW Department of Primary Industries (DPI) - Fisheries, WaterNSW, Nari Nari Tribal Council, scientists from Charles Sturt University engaged in monitoring the outcomes of

Commonwealth environmental water use, Murray-Darling Wetlands Working Group, The Nature Conservancy and the Murrumbidgee Environmental Water Advisory Group (EWAG) which includes local councils, the major irrigation corporations and private landholders.

Map MR1 Map of the Murrumbidgee catchment including major towns and headwater storage



Source: Courtesy of the Murray-Darling Basin Authority

12.2 Environmental objectives

Objectives for environmental water delivery in the Murrumbidgee River Valley are based on long-term environmental objectives in the Basin Plan; state long-term watering plans; the Ramsar site ecological character description for Fivebough and Tuckerbil swamps and local ecological knowledge.

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. The objectives are:

- Vegetation – Maintain or improve the condition and maintain or increase the extent of native riparian, in-channel, floodplain and wetland vegetation.
- Waterbirds – Increase waterbird abundance and maintain species diversity by supporting naturally triggered breeding events, and maintaining suitable refuge, feeding and breeding habitat.
- Native fish – Prevent loss of native fish species and improve population structure, distribution, and species abundance by supporting opportunities for movement, dispersal, reproduction, and recruitment.
- Other vertebrates – Provide habitat to support survival of other native aquatic species, including frogs and turtles; and support opportunities for reproduction and recruitment.

- Invertebrates – Provide habitat to support increased microinvertebrate and invertebrate survival, diversity, abundance and condition.
- Connectivity – Support longitudinal connectivity, including with the River Murray, and lateral connectivity (within constraints) between the river and floodplain and wetlands.
- Processes/water quality/resilience – Support in-stream and floodplain productivity; support nutrient, carbon and sediment transport; provide movement and dispersal opportunities for biota; create quality instream, floodplain and wetland habitat (including supporting water quality); and maintain or provide a diversity of drought refuge habitat across the landscape.

12.3 First Nations environmental watering objectives

Advice on environmental water objectives in the Murrumbidgee catchment has been provided through discussions with First Nations in the Murrumbidgee, particularly with the Nari Nari Tribal Council. Table MR1 includes just some of the objectives for the Murrumbidgee catchment raised. It is important to note these objectives do not represent the detail, depth and complexity of Nations' localised water-related objectives.

Some of these objectives sit outside the scope of water for the environment to influence, while for others, the link between water for the environment and the site or issues is not well understood. Environmental flows will aim to contribute to identified objectives, where possible. The Commonwealth Environmental Water Holder is committed to continuing to strengthen engagement with all Southern Basin First Nations to support those Nations to articulate objectives for water management.

The Commonwealth Environmental Water Office recognises the critical importance of strengthening involvement of First Nations people in environmental watering, and the importance of building transparent, respectful relationships with Traditional Custodians across the Basin. As such, we are developing a partnership agreement between the Nari Nari Tribal Council and the Commonwealth in relation to planning, delivery and monitoring of Commonwealth environmental water on Nari Nari Traditional Lands. The Partnership Agreement is nearing completion with the aim to maximise environmental outcomes over time by enabling the Nari Nari Tribal Council to facilitate environmental watering on Nari Nari Country, according to their lore and customary obligations. It is hoped, this will be the first of many partnerships with First Nations in the Murrumbidgee.

Table MR1 First Nations environmental water objectives for the Murrumbidgee system

Theme	Learnings
Waterways and Places in Need of watering	Murrumbidgee, Dry Lake, Yanga Lake, Billabong Creek, Wetlands, Billabongs, Floodplains, Creeks, Other places – parks, forests, islands, Major rivers, Tributaries, Ramsar-listed wetlands
River Flows and Connectivity	Improve water quality, improve timing and seasonality of flows, restore flows in degraded rivers, remove barriers and constraints, improve flows and quantity (rivers and general), restore wetland hydrology, improve river and or floodplain connectivity, and improve tributary flows
Vegetation	Old Man Weed, Cumbungi, Black Box, Lignum, River Red Gum, Grasses
Fish	Murray Cod, Yellowbelly, Catfish, Native fish
Waterbirds	Swan, Pelican, Ducks, Eastern Bittern, Sea eagle ^a , Black Swan
Other species	Turtles, Frogs, Murray Cray, Shrimp, Mussels, Platypus, Yabbies, Water Rat (Rakali), Macroinvertebrates, Emu ^a , Kangaroo ^a , Birds

^aWater for the environment targeting other environmental outcomes may influence this species or objective

12.4 Recent conditions and seasonal outlook

12.4.1 Recent conditions and environmental water use

The Murrumbidgee Valley experienced dry conditions from early 2017 up until early 2020 when wetter conditions prevailed, contributing to the dry conditions easing (BOM 2021). Allocations against Murrumbidgee regulated high security, general security and conveyance entitlements reached 100% in January 2021.

The Murrumbidgee Valley experienced wet (about 25th percentile) conditions in 2020–21 (DPIE 2021a). That is, based on long term inflow statistics, about 25 out of 100 years would generally experience conditions that are wetter than those experienced across the year.

With the reasonably wet conditions and high-water resource availability in the valley, the primary focus for use of Commonwealth water for the environment was to maintain, and where possible, improve the health and resilience of aquatic ecosystems. This included the large-scale provision of water to the Lowbidgee floodplain, a flow down the Murrumbidgee River and small-scale water delivery to a network of wetland sites across the Murrumbidgee valley, including two new sites, with the first pumping of water to Rhyola Swamp and Middle Wetland in the Yanco/Billabong Creek system.

Delivery of Commonwealth and NSW water for the environment successfully:

- triggered and supported breeding of over 15,000 straw-necked and 3000 glossy ibis nesting pairs, including smaller numbers of many other species, at Eulimbah Swamp in Gayini Nimmie-Caira. This very large colony was established and supported solely by water for the environment
- supported over 20 waterbird breeding events across the catchment, 18 in the Lowbidgee' two in the mid-Murrumbidgee and one at Wanganella Swamp; with breeding of numerous species including threatened Australasian and little bitterns, egrets, spoonbills, herons, cormorants, darters, threatened blue-billed and freckled ducks, and brolgas
- supported six species of frogs (barking and spotted marsh frogs, Peron's tree frog, plains froglet, inland banjo frog and the threatened southern bell frog); with successive years of delivering water for the environment supporting the return of threatened southern bell frog populations in the Lowbidgee to pre-Millennium Drought numbers
- supported golden perch spawning and recruitment in the deep creek systems on the Yanga National Park floodplain and provided fish passage between barriers (weirs) in the Lowbidgee and between the Murrumbidgee and Murray rivers. The flow also provided lateral connection to floodplain creeks and lakes in Yanga National Park, enabling native fish to move between the river and floodplain creeks and lakes, as well as providing a critical exchange of carbon and nutrients
- led to the discovery, and supported, a small population of unspeckled hardy-head at Coonancoocabil Lagoon in the mid-Murrumbidgee: this species is very rare in the Murrumbidgee
- supported populations of a range of native fish including carp gudgeon, Australian smelt, flathead gudgeon, bony-bream, rainbow fish, Murray cod and golden perch
- supported an increased abundance of deep-water tolerant aquatic plant species such as common and red watermilfoil, common spike rush and floating pondweed in the Lowbidgee. Also promoted the emergence of new lignum, common spike rush, water primrose, starworts, and mud flat colonising species such as old man weed and lesser joyweed. Black-box trees that had been in poor health at Avalon Swamp in Gayini-Nimmie-Caira responded well to environmental watering which triggered their flowering along with establishing areas of nardoo, azolla, water primrose and swamp lily

supported all three Murrumbidgee turtle species (broad shelled, eastern long-necked and Macquarie River turtles).

Learn more about previous [Commonwealth environmental water use in in the Murrumbidgee River Valley](#).

12.4.2 Seasonal outlook

The Bureau of Meteorology’s seasonal outlook for June to August 2021 indicates that rainfall is likely to be above average across most of the Murrumbidgee River catchment with a greater than 75% chance of above median rainfall (BOM 2021). Additionally, the chance of exceeding maximum temperatures over the coming months is variable across the catchment, ranging from 60% in the eastern end of the valley reducing to 45% at the western end of the valley (BOM 2021).

This forecast should allow expanded system-scale and co-ordinated cross-catchment watering actions.

12.4.3 Water availability

The volume of Commonwealth environmental water carried over in Murrumbidgee River Valley for use in 2021–22 is 81.9 gigalitres, representing approximately 24.3% of general security and conveyance entitlement. In the Murrumbidgee regulated water source, general security and conveyance licences can carry over water up to a maximum of 30% of entitlement, the account limit (allocation plus carryover) is 100% of entitlement.

Allocations against Commonwealth water entitlements in the Murrumbidgee River Valley are determined by state governments and will vary depending on inflows. In the 1 July 2021 Water Allocation Statement (DPIE 2021b), opening allocations to high security entitlements are 95%, 30% for general security entitlements, and conveyance entitlements as per the valley’s water sharing plan.

Based on the available volume of water held by the Commonwealth and other water holders (including carryover and forecast allocations), as well as recent and forecast catchment conditions, it is expected that the overall resource availability will be moderate to high in 2021–22.

12.4.4 Environmental demands

The environmental water demands for assets in the Murrumbidgee River Valley in 2021–22 are represented in Table MR2. A low-level mid-Murrumbidgee reconnection is a high priority under all water resource scenarios, and under current forecasts there is sufficient environmental water for this action to proceed.

Table MR2 Environmental demands and watering priorities, 2021–22, and outlook for coming year, Murrumbidgee catchment

Environmental assets	Target values	Indicative demand (for all sources of water in the system)			2021–22		Implications for future demands
		Flow/volume	Required frequency (maximum dry interval)	Watering history (from all sources of water)	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
Mid-Murrumbidgee Wetlands^a (includes pumping to Toogimbie Indigenous Protected Area) (PU 4, 5, 6, 9 and may also contribute flows in PU 7, 8, 10, 11, 12, 13)	Critical refuge habitat, aquatic vegetation, waterbirds, native fish, frogs, turtles, nutrient dispersal	Infrastructure assisted delivery to individual high priority wetland assets targeting provision of refuge habitat and maintenance of wetland vegetation (minimum of 4 GL required under a very low inflow scenario to support critical refuge requirements) (PU 6)	8 in every 10 years – annual (2 years)	Demand met or partially met over the last 5 years	HIGH to CRITICAL Provide refuge habitat for aquatic animals and maintain established aquatic habitat. However overbank connection is preferred	High Potential for water use under Very Low to Moderate inflow scenarios Up to 15 GL (volume contributed will be dependent on resource availability/antecedent conditions, with a minimum of 4 GL required under a Very Low inflow scenario)	HIGH to CRITICAL
		Tombullen storage releases to augment flows over 13 GL/day at Darlington Point (PU 6, 7, 8)	7–8 in every 10 years (2 years)	Demand partially met over the last 3 years	HIGH The condition of the mid-Murrumbidgee wetlands is generally poor due to a lack of inundation.	High Potential for water use under Moderate to High inflow scenarios subject to natural flow event triggers Up to 10 GL per event	HIGH
		Minimum of 15.5 GL/day at Darlington Point for up to 6 days plus a gradual recession targeting low-lying wetland vegetation and aquatic habitat up to 180 GL (multiple PU's)	7–8 in every 10 years (2 years)	Demand met 2 out of the last 5 years, last met 2017–18.	HIGH to CRITICAL The condition of the mid-Murrumbidgee wetlands is generally poor due to a lack of inundation.	Up to 170 GL under Moderate to High inflow scenarios	MODERATE
		Augment Airspace and/or Translucent Flow releases to maximise flow peak for inundation of mid-Murrumbidgee wetlands. Up to 40 GL ordered from opposing dam or other storage.	Opportunistic in response to natural cues and river operations	Opportunistic in response to natural cues and river operations	HIGH The condition of the mid-Murrumbidgee wetlands is generally poor due to a lack of inundation.	Up to 40 GL under Moderate to High inflow scenarios	HIGH
Murrumbidgee Irrigation (MI) Area Ramsar sites (Fivebough and Tuckerbil wetlands) and includes other important wetlands in MI Area (PU 14)	Ramsar ecological character, waterbirds, aquatic vegetation	Fivebough 500 ML to inundate 60% of wetland.	Fivebough: Shallow water 9 in every 10 years.	Demand met over the last 7 years	HIGH Required to maintain ecological character under Ramsar	High Potential for water use Minimum of 2 GL under a Very Low inflow scenario	HIGH
		Tuckerbil 500 ML to fill	Fill Tuckerbil 4 of every 10 years	Demand met over the last 6 years	HIGH Required to maintain ecological character under Ramsar	High Potential for water use. Up to 5 GL under Low inflow scenario	HIGH
Yanco/Billabong/Forest Creeks System (PU 12, 13)	Low-lying wetland vegetation and aquatic habitat, and native fish spawning and movement	Up to 20 GL in-channel, targeting up to 1400 ML/day at Yanco Creek off-take. Objectives also achieved by a mid-Murrumbidgee wetlands reconnection flow	7 in every 10 years (2 years)	Demand met or partially met in 3 of the last 6 years, however watering required to maintain condition of wetland-floodplain vegetation	MODERATE Watering, required to maintain the good condition of wetland-floodplain vegetation	Moderate Potential for water use Up to 10 GL under Moderate to High inflow scenarios. Supplementary use prioritised if available.	MODERATE Subject to natural cues
Yanco Creek System – Wanganella and Rhyola Swamps (PU 12, 13)	Aquatic vegetation, waterbirds	Pumping up to 2.5 GL	7–8 in every 10 years (2 years)	Demand met 3 out of the last 6 years	CRITICAL Prevent loss of aquatic vegetation species (cumbungi rhizomes)	High Potential for water use Up to 2.5 GL under Very Low to Moderate inflow scenarios	HIGH
Yanco Creek System – Wanganella, Rhyola and Old Coree Swamps (PU 12, 13)	Wetland and black box vegetation communities	Up to 6 GL	3 in every 10 years (3 years)	Demand met or partially met in 3 of the last 6 years	MODERATE Watering following natural cues to maintain condition of wetland-floodplain vegetation	Moderate Potential for water use up to 4 GL if natural flow event triggers an opportunity under Moderate to High inflow scenario. Supplementary use prioritised if available.	LOW, subject to natural cues

Environmental assets	Target values	Indicative demand (for all sources of water in the system)			2021–22		Implications for future demands
		Flow/volume	Required frequency (maximum dry interval)	Watering history (from all sources of water)	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
Lowbidgee - Core refuge and permanent aquatic habitat sites (PU7)	Critical refuge habitats	Up to 73 GL targeting critical refuge habitat requirements (minimum of 8 GL is required under a Very Low inflow scenario to meet these needs)	Annual	Demand met over the last 6 years	HIGH to CRITICAL Annual watering required for critical habitat requirements	High Potential for critical/permanent habitats. Volume contributed will be dependent on resource availability/antecedent conditions, with a minimum of 5 GL required under a Very Low inflow scenario increasing to 50 GL under Moderate inflow scenarios Supplementary use prioritised if available.	HIGH to CRITICAL
Lowbidgee – Rookery sites (PU7)	Naturally triggered colonial waterbird breeding	Up to 30 GL	As required in response to naturally triggered colonial bird breeding event	As required	HIGH Support successful completion of waterbird breeding events	High Potential, if colonial waterbird breeding is triggered under Moderate to Very High inflow scenario	HIGH
Lowbidgee - North Redbank (PU7)	Wetland vegetation and habitat for native fish, frogs, turtles, and waterbirds	Up to 60 GL ^b	River red gum forest and spike rush wetlands 1–3 years (3 years)	Met or partially met over the last 6 years	MODERATE Watering following natural cues, to maintain the good condition of wetland-floodplain vegetation	Moderate Potential for wetland inundation Up to 40 GL under Moderate to High inflow scenarios Supplementary use prioritised if available.	LOW, subject to natural cues
Lowbidgee - Yanga National Park (PU7)	Wetland vegetation and habitat for native fish, frogs, turtles, and waterbirds	Up to 50 GL ^b	River red gum forest and spike rush wetlands 1–3 years (3 years)	Met or partially met over the last 6 years	HIGH Watering required to maintain deep creek fish refuges and condition of wetland-floodplain vegetation	High Potential for wetland inundation Up to 30 GL under Moderate to High inflow scenarios Supplementary use prioritised if available.	MODERATE, subject to natural cues
Lowbidgee - Gayini Nimmie-Caira (PU7)	Wetland vegetation and habitat for native fish, frogs, turtles, and waterbirds	Up to 50 GL ^b	Refuge habitat annual Lignum dominated wetlands 1 to 5 years, with duration of up to 7 months	Met or partially met over the last 6 years	HIGH Watering following natural cues to maintain the good condition of wetland-floodplain vegetation	High Potential for wetland inundation Up to 30 GL under Moderate to High inflow scenarios Supplementary use prioritised if available.	MODERATE, subject to natural cues
Lowbidgee - Fiddlers-Uara (PU7)	Wetland vegetation and habitat for native fish, frogs, turtles, and waterbirds	Up to 20 GL	Black box and lignum wetlands every 3 to 7 years	Met or partially 3 out of the last 7 years	MODERATE Watering following natural cues to maintain the good condition of wetland-floodplain vegetation	Moderate Potential for wetland inundation Up to 15 GL under High inflow scenarios Supplementary use prioritised if available.	LOW, subject to natural cues
Lowbidgee - Western Lakes (PU7)	Maintain open water habitats and floodplain vegetation	Up to 30 GL	Wetland habitats and open water, black box, and lignum wetlands every 3 to 7 years	Met or partially met over the last 6 years	LOW Watering following natural cues, to maintain open water bodies and good condition of wetland-floodplain vegetation	Low Potential Up to 15 GL under Moderate to High inflow scenario	MODERATE
Lowbidgee full system watering (PU7)	Waterbird recovery, improve floodplain habitat condition	Up to 180 GL for Basin-wide waterbird habitat and future population recovery.	Opportunistic based on natural occurring rain and flow events	Met or partially met over the last 6 year	MEDIUM Improve the complexity and health of priority waterbird habitat to maintain species richness and aid	Low Potential Up to 120 GL under High inflow scenario. Lowbidgee supplementary allocations will be prioritised if made available under High to Very High inflow scenarios.	HIGH

Environmental assets	Target values	Indicative demand (for all sources of water in the system)			2021–22		Implications for future demands
		Flow/volume	Required frequency (maximum dry interval)	Watering history (from all sources of water)	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
					future population recovery		
Murrumbidgee River channel, distributaries, and anabranches (PU 6, 7, 8, 9, 10, 11, 12, 13)	Native fish spawning, recruitment, movement, and dispersal.	Contribute up to 10 GL from Tombullen storage to higher river flows (freshes) in spring-summer	7 in every 10 years	Met 2 out of the last 7 years	MODERATE Watering following natural cues, required to continue recovery of native fish populations.	Moderate Potential Up to 10 GL if natural flow event triggers an opportunity under Moderate to High inflow scenario.	LOW
	Native fish movement and recruitment, productivity, and in-stream vegetation	Moderate in-channel pulse (flows >3500 ML/day at Balranald) up to 50 GL	7 in every 10 years	Met 3 out of the last 6 years	MODERATE Native fish populations in the lower Murrumbidgee River are in poor condition. Water required for improved fish passage and connectivity, aquatic habitat, and riverine productivity	Moderate Potential Up to 30 GL under Moderate to High inflow scenarios	MODERATE
	Native fish, wetland vegetation	Distributary and anabranch freshes to restore flow components most impacted by river regulation up to 15 GL	7 in every 10 years to annual	Demand met 2 out of the last 6 years	MODERATE Watering following natural cues to maintain the good condition of wetland-floodplain vegetation	Moderate Potential subject to natural cues up to 10 GL	MODERATE, subject to natural cues
	Water quality	Contribute to managing water quality issues within in-stream and wetland environments across the Murrumbidgee Catchment	Contingency in response to poor water quality	As required	CRITICAL Provide refuge habitat for aquatic animals due to poor water quality, including potential hypoxic conditions.	Contingency in response to poor water quality/aquatic habitat availability. This may include up to 15 GL contingency under very low to low inflows, in the absence of IVT (Lower Murrumbidgee weir pool stratification, high risk fish kills). Or may include a very large contingency volume (when allocations allow) under very high inflows and natural flooding to mitigate potential hypoxic blackwater affects	CRITICAL (Contingency)
Junction Wetlands (PU8)	Wetland vegetation and habitat for native fish, frogs, turtles, and waterbirds	Flows greater than 5 GL/day at d/s Balranald Weir and >10 GL/day on the Murray at Murrumbidgee confluence	5 in every 10 years	Demand met in 2 of the last 6 years	HIGH The condition of the Junction Wetland is generally poor due to a lack of inundation	Low Potential under low inflows. Likely to be achieved by other environmental watering actions and through Lowbidgee Supplementary allocations under Moderate to High inflow scenarios	HIGH
		Flows greater than 7 GL/day at d/s Balranald Weir	5 in every 10 years	Demand met in 1 of the last 6 years	HIGH The condition of the Junction Wetland is generally poor due to a lack of inundation	Low Potential under low inflows. Likely to be achieved by other environmental watering actions and through Lowbidgee Supplementary allocations under Moderate to High inflow scenarios	HIGH

Environmental assets	Target values	Indicative demand (for all sources of water in the system)			2021–22		Implications for future demands
		Flow/volume	Required frequency (maximum dry interval)	Watering history (from all sources of water)	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
		Pumping up to 4 GL to individual high priority wetland assets	7–8 in every 10 years (2 years)	Demand met in 5 of the last 6 years	MODERATE To support continued recovery of wetland vegetation and provide refuge habitat	Moderate Potential for water use up to 4 GL under Very Low to Moderate inflow scenarios (volume contributed will be dependent on resource availability/antecedent conditions, with a minimum of 1.5 GL required under a Very Low inflow scenario)	HIGH

Note: Planning Units (PU) 4 – 14. Identified in the Murrumbidgee Long Term Water Plan Part B (NSW DPIE 2020b).




a Difference in filling height (i.e. flows required to fill a wetland) vary among the lagoons that make up the mid-Murrumbidgee wetlands, and so their condition and watering requirements vary accordingly.

b Cumulative volume - includes volume allocated for this asset under Lowbidgee Core refuge and permanent aquatic habitat.




PU4: Murrumbidgee River – Tumut River Junction to Berembed Weir	PU8: Murrumbidgee River – Balranald to Murray	PU12: Lower Yanco Creek to Lower Billabong Creek
PU5: Murrumbidgee River – Berembed Weir to Gogeldrie Weir	PU9: Beavers and Old Man’s Creek	PU13: Lower Billabong and Intersecting Streams
PU6: Murrumbidgee River – Gogeldrie Weir to Maude Weir	PU10: Upper Yanco Creek	PU14: Murrumbidgee Infrastructure Dependent Floodplain Wetlands
PU7: Lower Murrumbidgee Floodplain	PU11: Colombo & Billabong Creeks	

Key

Potential watering in 2020–21

	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)

12.5 Water delivery in 2021–22

Based on the demand for water for the environment, water availability (supply), and catchment conditions, the overall purpose for managing Commonwealth water for the environment in the Murrumbidgee River Valley in 2021–22 is to continue to improve, and where possible recover, important wetland habitats and threatened species populations specifically by undertaking large system-scale actions to link the floodplain to the main river channel. Specifically, for the mid-Murrumbidgee wetlands the purpose is to maintain and ensure their ecological capacity for recovery and remains a priority subject to available allocations.

Planning for water delivery in the Murrumbidgee River Valley considers all water resource availability scenarios from extreme dry to wet, thereby enabling water managers to respond efficiently and effectively to changing conditions. Delivery of water for the environment to many sites and landscapes in the Murrumbidgee River Valley is scalable (i.e., increase the area, volume delivered, and number sites inundated on the floodplain), depending on the volume of water available and catchment conditions. For instance, should climatic conditions and water availability improve there may be opportunities to increase the number of sites inundated on a floodplain, including sites that require substantial volumes of water to fill.

In the Murrumbidgee Valley, the availability of water for the environment forecast for the beginning of 2021–22 will likely enable water managers to undertake environmental watering actions planned under all dry and moderate resource scenarios, including very high priority actions identified under wet to very wet resource scenarios.

A very high priority for Commonwealth water for the environment remains a managed low-level mid-Murrumbidgee wetlands reconnection action. Wetlands in this area are generally in poor condition due to lack of repeated inundation. Ideally, a low-level wetlands reconnection with the Murrumbidgee River is required annually to enable the recovery of wetlands and their aquatic ecosystems. Low-level wetlands were last inundated by the Murrumbidgee River through a managed reconnection in winter 2017. The action is subject to dam release capacities and assessments of potential third-party impacts. The watering action will also contribute to downstream demands, including Yanco Creek, the Lowbidgee floodplain including the Junction Wetlands and potentially the lower Murray (where ‘return flows’ are available under NSW “pre-requisite policy measures”). Should the wetlands receive water from natural flows in winter-spring, a reconnection flow for these wetlands will still remain a high priority for autumn.

Under moderate and wet conditions, large-scale wetland and floodplain inundation including river-floodplain connection will be targeted to restore components of natural flow regimes in the Lowbidgee and Yanco-Billabong-Forest Creek systems. These flows aim to disperse essential nutrients, plants and animals, and support reproduction and improve condition of native plants, waterbirds, native fish, frogs, turtles and other water dependent animals. These broader scale watering actions will help to improve the condition and resilience of important sites in the Murrumbidgee River Valley. They also build resilience of the system to help sites to maintain condition and function in dry years and to help cope with climate change.

Floodplain habitats have been found to be critical for native fish spawning, growth, and recruitment (particularly golden perch) and provide high-quality refuges during extreme drought conditions. Therefore, river-floodplain connectivity in the lower Murrumbidgee may

also be supported by in-channel flows targeting native fish movement and recruitment, including for floodplain to river movement, and in-channel productivity.

Note that under wet or very wet conditions, unregulated flows are likely to meet many of the Murrumbidgee River Valley’s environmental demands. However, water for the environment may be used to extend the duration of unregulated flows or undertake follow-up watering to achieve environmental watering objectives, subject to constraints and third-party impacts.

If a decline in water quality of in-stream or wetland environments across the Murrumbidgee catchment occurs due to low inflows and dry conditions, or very wet conditions, water for the environment will target protecting refuge habitats for aquatic animals, including for native fish, subject to available allocations.

Additional environmental demands may also be identified during the water year as new information becomes available. Note, under certain levels of water availability, watering actions may not be pursued for a variety of reasons. For example, this may be due to the environmental demand being met by unregulated flows or the ability to deliver environmental water may be limited by constraints or infrastructure works and/or risks.

12.6 Monitoring and lessons learned

12.6.1 Monitoring

Operational monitoring is undertaken for all Commonwealth environmental watering actions and involves collecting on-ground data with regard to environmental water delivery such as volumes delivered, impact on the river systems hydrograph, area of inundation and river levels. It can also include observations of environmental outcomes.

The Monitoring, Evaluation and Research (MER) Program (previously the Long-Term Intervention Monitoring Project 2014–2019) has sites in the mid-Murrumbidgee Wetlands, Lowbidgee Floodplain and Murrumbidgee River as focus areas. It aims to understand the environmental response from Commonwealth environmental watering with respect to the targeted objectives by carrying out monitoring of site condition over many years.

Learn more about [monitoring activities funded by the CEWO in the Murrumbidgee River Valley](#).

12.6.2 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 lessons are incorporated into the way water for the environment is managed.

Key findings and recommendations from environmental monitoring projects (Baldwin 2019; Wassens et al. 2021; Wassens et al. 2020 a and b; Kopf et al. 2019; Wassens et al. 2019 b and c) in the Murrumbidgee River Valley is summarised in Table MR3.

Table MR3 Key lessons learned in the Murrumbidgee River Valley

Theme	Lesson learned
Native fish	<ul style="list-style-type: none"> • Spawning and recruitment of native fish species, such as golden perch, can occur from within the floodplain system. Spawning of golden perch on the floodplain can be triggered using environmental flows, as demonstrated by monitoring in 2018 and 2021. • Floodplain habitats may be critical for golden perch spawning, growth and recruitment, and importantly provide rare refuges of high-quality habitat and productivity during extreme drought conditions. Management decisions to deliver environmental water to inundate and maintain Lowbidgee floodplain habitats during spring and summer are important to maintain viable native fish populations, and to provide food and habitat for resident populations of fish, frogs and a diverse assemblage of waterbirds. • Poor recruitment to the juvenile stage was found for large-bodied native fish species within the main river channel although young of year golden perch have been detected in floodplain wetlands. • Further locations and water delivery options could be investigated to improve off-channel nursery habitat for golden and silver perch. • Spawning of golden or silver perch in the Murrumbidgee River does not appear to be translating to recruitment for either of these species. As stocking of silver perch does not occur in the Murrumbidgee and golden perch stocking is thought to contribute to around 14% of the golden perch population the Narrandera zone, it can be assumed that the population is comprised of wild adults that spawned and recruited locally. Poor young of year recruitment response have also been exhibited by Murray cod, with abundance of juveniles being considerably lower in 2018–19 compared with 2014–15 and 2015–16, but similar to those recorded in 2016–17. The drivers of successful recruitment, the key locations which support juveniles and the causes for the recent failures in recruitment remain unknown. • Since monitoring commenced in 2014, there has been little evidence to suggest that managing discrete flow peaks within the monitored reaches of the mid-Murrumbidgee influenced native fish spawning. This might be in part due to the already higher water flows occurring in the mid-Murrumbidgee compared to other parts of the river, with irrigation deliveries creating conditions suitable for spawning throughout the breeding season. • Wetland native fish species diversity was highest in wetlands that have an area of permanent water, including Avalon swamp, Telephone Creek and Waugorah Lagoon.
Frogs	<ul style="list-style-type: none"> • Breeding of many frog species, including the southern bell frog (EPBC Act vulnerable), is triggered by rising water levels in wetlands during October and November. Therefore, watering actions in early spring are important to enhance frog breeding activity and recruitment. • Southern bell frog numbers have now reached pre-Millennium drought levels in the Lowbidgee. The combination of watering actions targeted at maintaining refuge habitat, complemented by larger deliveries during spring and summer should be continued. • The southern bell frog is highly sensitive to environmental water management and has very narrow flow requirements – requiring shallow, well vegetated areas with longer duration. Southern bell frogs also appear to be sensitive to high fish numbers and pumping of wetlands has been used with considerable success to support southern bell frog populations in the Lower Murray (NSW) and Lower Murray (SA) and the mid-Murrumbidgee (Mason 2020, Waudby et al. 2021).
Turtles	<ul style="list-style-type: none"> • Maintaining the availability of permanent water holes, particularly at Mercedes Swamp, Telephone Creek and Wagourah Lagoon, refuge sites is important to support high turtle numbers. • Evidence of turtle recruitment remains limited most likely due to high levels of nest predation. <ul style="list-style-type: none"> – Ongoing fox control at key wetlands will also be important for maximising nesting success.

Theme	Lesson learned
Waterbirds	<ul style="list-style-type: none"> – Investigate opportunities for head-starting which can involve collecting eggs to hatch in captivity before release of hatchlings. • Breeding of turtles is influenced by food availability in previous year. • Higher waterbird species richness and abundance has been observed at sites that were inundated by water for the environment compared to wetlands that were dry for extended periods. • Where possible, Commonwealth environmental water should be prioritised to provide annual seasonally inundated habitat (spring-summer) for waterbirds in the Lowbidgee floodplain and mid-Murrumbidgee wetlands <ul style="list-style-type: none"> – Deliver flows in early spring rather than late summer, and top-up to increase duration into autumn • Most waterbirds commence breeding in spring, however, the stimulus for breeding is usually a combination of season, rainfall and flooding. • When breeding occurs, water levels in active sites need to be maintained into summer months to ensure the successful fledging of young birds. • In the years following large-scale flooding events, provision of environmental water is likely to be extremely important in creating feeding habitat to support survival of young birds. • When there is limited natural overbank flooding, inundating floodplain habitat to create foraging habitat would benefit waterbird populations in the Murray-Darling Basin by promoting the survival of juvenile and adult waterbirds. • Maintaining refuge and foraging habitat for waterbirds during dry periods, should also consider watering wetland sites earlier in spring to increase productivity the availability of shallow water and mudflats as well as supporting longer duration inundation duration of floodplain inundation. • Keeping the water levels stable at Wanganella Swamp during the months of November, December and January is paramount. The water should be rising in September and rising slightly in October before stabilising in November, December and January, and then slowly drawing down in February/March. <ul style="list-style-type: none"> – Straw-necked ibis require 60 to 90 cm of water under the reeds or lignum for nesting, which also satisfies requirements for breeding of many other waterbird species. • The draw-down of large floodplain lake systems including Yanga Lake can provide high value foraging habitat for waterbird species. Timing the drawdown of lakes to spring or late summer also coincides with the movement patterns of migratory shorebirds – benefiting populations that extend well beyond the Murrumbidgee Catchment.
Vegetation	<ul style="list-style-type: none"> • Despite the wide range of hydrological regimes and geomorphologies of wetlands in the Murrumbidgee, there is a clear trend that wetlands which have received environmental water more frequently support higher species richness of water dependent vegetation species and lower numbers of exotic species. • Inundating Wagourah Lagoon and Telephone Creek in the Lowbidgee during years of high water availability should be a priority. And future watering actions at Avalon Swamp should aim to achieve complete inundation of the main wetland for approximately 8 weeks, to support the growth and reproduction of key species. • River red gum encroachment remains a concern in the mid-Murrumbidgee wetlands, particularly at McKennas Lagoon. Given the current level of river red gum at this and other wetlands, mechanical removal coupled with repeat inundation over several years may be required for restoration. • Pumping environmental water into wetlands within the mid-Murrumbidgee can limit the biomass of carp entering the wetland, which in turn can improve germination and establishment of water dependent plant species. <ul style="list-style-type: none"> – During natural reconnections, it is likely that these wetlands will again be recolonised by large carp. Managed drawdowns in autumn or winter may be required to again reduce carp biomass and support vegetation establishment.
Microinvertebrates	<ul style="list-style-type: none"> • Higher river levels and cooler temperatures in the Narrandera zone may impact the development of a productive and diverse microinvertebrate community.

Theme	Lesson learned
Processes Connectivity	<p data-bbox="520 237 1385 320">Environmental flows that inundate dried sediments without creating stable high flows or colder water temperature may be important for maintaining high levels or riverine microinvertebrate density.</p> <ul style="list-style-type: none"> <li data-bbox="483 331 1385 387">• Watering actions that allow key wetlands to draw down and temporarily dry out will contribute to maintaining microinvertebrate densities. <p data-bbox="520 405 1385 656">Although rates of metabolism were low during 2019–20, overall, rates of metabolism have remained relatively stable over the past six years despite considerable variability in flow volume. There seems to be little capacity for Commonwealth environmental water to have a significant influence on the rates of stream metabolism and nutrient availability via manipulation of water levels in the Murrumbidgee River within existing capacity constraints under normal flow conditions. However, previous work has shown that managed return flows do have the capacity to influence riverine nutrient availability at local scales, as was the case of the Redbank return flows undertaken in 2014–15.</p> <ul style="list-style-type: none"> <li data-bbox="483 667 1385 801">• Broad-scale wetland reconnections and periods of low flow are necessary to promote resources for river food webs. Future planning of watering actions that allow for wetland reconnections either via managed return flows or by generating peaks in river height may assist with the mobilisation of carbon and nutrients from the floodplain to the river.
Water Quality	<ul style="list-style-type: none"> <li data-bbox="483 824 1385 1182">• Monitoring of weir pool stratification (the establishment of a thermocline, with warmer, oxygenated water above and cooler, low dissolved oxygen below) and hypoxic water management in the Lower Murrumbidgee River in 2019 showed that high temperatures and low flow conditions have the potential to adversely affect water quality. Mixing of the hypoxic bottom water with oxygenated surface water can result in low dissolved oxygen concentrations throughout the water column thereby potentially causing fish kills. Water quality can be improved, and fish kills mitigated against by: <ul style="list-style-type: none"> <li data-bbox="520 1059 1385 1115">– steadily increasing in-channel flows and gradually releasing hypoxic water from weirs, and <li data-bbox="520 1126 1385 1182">– exporting hypoxic water from weirs onto the floodplain using existing regulators. <li data-bbox="483 1193 1385 1294">• In the absence of Inter Valley Transfers during Summer, targeted end-of-system flow rates alone (under the Murrumbidgee Water Sharing Plan) are inadequate to maintain acceptable water quality thresholds for aquatic biota under extreme climatic conditions. <li data-bbox="483 1305 1385 1462">• Physicochemical measurements from monitored wetland sites during the previous six-year period (2014–20) have been largely consistent and remained within acceptable upper and lower ranges reflecting that wetlands are in good condition. <ul style="list-style-type: none"> <li data-bbox="520 1406 1385 1462">– Delivering water in spring to managed wetlands more closely matches natural inundation and reduces the risk of hypoxic black water events.
Hydrology	<ul style="list-style-type: none"> <li data-bbox="483 1485 1385 1653">• Water for the environment is the primary driver of ecological responses for water dependent species in the mid and lower Murrumbidgee floodplains. Maintaining core permanent refuge habitats and providing foraging opportunities for resident species should be a priority in all water years. In years of moderate and high-water availability, inundation of larger, continuous areas of floodplain habitats that support breeding opportunities should continue to be a priority.
Operational	<ul style="list-style-type: none"> <li data-bbox="483 1675 1385 1809">• Very dry conditions occurred through the 2019–20 water year and watering actions were undertaken in-line with very low water availability. Environmental water deliveries were the lowest since monitoring began in 2014. Under these conditions, watering actions maintained critical refuge habitats for water dependent animals and vegetation condition and resilience in key wetland and floodplain habitats. <li data-bbox="483 1821 1385 1957">• Removal of carp from a wetland prior to pumping, either through physical removal and/or short-term drying of the wetland, have shown to have positive benefits for frogs and vegetation. It is recommended that this management intervention be implemented when carp numbers increase and declines in vegetation and tadpole diversity become apparent.

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