Seasonal Watering Proposal 2022-2023

Barmah-Millewa Forest (for VEWH with SCBEWC addendum)

GOULBURN BROKEN
CATCHMENT MANAGEMENT AUTHORITY

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For further information, please contact:

Goulburn Broken Catchment Management Authority
P.O. Box 1752, Shepparton 3632
Phone: (03) 5822 7700
Website: www.gbcma.vic.gov.au

Cover Photograph:

Rufous Night-heron with nuptial plumage at Boals Deadwoods, Barmah National Park (*Trail camera image RCNX0346, 11/12/2021*).

Executive Summary

Purpose:
This document provides the additional information required by the Victorian Environmental Water Holder (VEWH) for all Victorian seasonal watering proposals. This document, in addition to the 2022-23 SCBEWC Environmental Water Proposal template that has been jointly prepared for Barmah-Millewa Forest with NSW government, forms the Seasonal Watering Proposal for Barmah-Millewa Forest and outlines the combined Goulburn Broken Catchment Management Authority (GB CMA) and NSW Department of Planning, Industry and Environment (DPIE) priorities for the use of environmental water in Barmah-Millewa Forest in 2022-23.

Seasonal review of 2021-22:
Water management in 2021-22 was characterised by the following:

- Translucent Regulator operations occurred in August and September where regulators were open irrespective of river levels to divert some water through both Barmah and Millewa forests until environmental water releases commenced in mid-October (water losses to the forest are underpinned by environmental water accounts).
- Four main natural flood peaks occurred between late-winter and spring (each consisting of two or more events that sustained the flood events well above-channel capacity), the largest peaking at 45,700ML/d in early September.
- Environmental water management bridged successive natural flood peaks in winter-spring to reduce the rate of recession off the lower floodplain and maintain flows at 15,000ML/d (the maximum permissible for managed releases).
- Two unseasonal natural flood events occurred in January and February resulting in the lower floodplain to have been inundated for seven months.
- Environmental water was delivered directly to Boals Deadwoods for 2.5 months between December and February to successfully maintain an ibis nesting colony (431 nests; 79% Australian Whire Ibis, 19% Straw-necked Ibis).
- A blackwater event followed the summer natural flood pulses through Barmah Forest, however no fish deaths were detected.
- Approximately 55% of Barmah Forest and 55% of Millewa Forest floodplain was inundated.
- Under modelled Natural Conditions (i.e., without regulation), the river would have peaked at 78,000ML/d in August and 83,000ML/d in September and would have inundated all the active floodplain.
- Staged closure of regulators occurred at the end of flood peaks in attempt to permit fish to exit the waterways into the Murray River through the regulators before they were fully closed. The success of this strategy was assessed by tracking the movement of fish located behind the regulators. Results are yet to be analysed.
- Flows were generally equally shared between Barmah and Millewa forests, with slight bias to maintaining all Millewa Forest regulators fully open, especially when targeting the exit of fish at the conclusion of the regulators having to be closed.

Very good environmental outcomes resulted, including strong Moira Grass growth and flowering (especially where protected by feral horse exclusion areas in Barmah Forest), native fish breeding and some waterbird breeding where flooding occurred. Of note was the establishment of a bird breeding colony of approximately 1000 birds in Barmah and Millewa forests, predominantly Australian White Ibis but also Straw-necked Ibis and Royal Spoonbills, which bred and successfully fledged young.

Environmental objectives, potential watering actions and scenario planning for 2022-23:

The watering strategy planned to be undertaken in the forthcoming financial year (2022-23) intends to bias Barmah Forest (Victoria) given alternating annual arrangements with NSW agencies managing Millewa Forest while current channel capacity constraints exist and/or environmental water volumes are restrictive. There may also be a need for MDBA River Operations to divert water orders destined for downstream of Barmah-Millewa Forest solely through the Barmah Forest section, given the greater return flows to the Murry River than if passed through Millewa Forest.

The overarching objective for water management at Barmah-Millewa Forest in 2022-23 is therefore to minimise hypoxic blackwater development and to promote spring flooding with an autumn dry period on the Floodplain Marsh plains, as well as achieving native fish and waterbird breeding outcomes. Additionally, as it is Barmah Forest's turn to take unseasonal flooding events in 2022-23 as part of the annually-alternating reciprocal arrangement, water management will attempt to minimize unseasonal flooding on Floodplain Marsh plains by diverting unseasonal flooding to Giant Rush dominated wetlands in Barmah Forest such as Boals Deadwoods and Top Island.

To achieve this, the broad aims of 2022-23 watering proposal for Barmah-Millewa Forest are to:

- Minimise hypoxic blackwater development through early season flushing.
- Maintain drought refuge for floodplain-specialist fish species and turtles.
- Enhance vegetation health of wetlands, watercourses and forest communities on the lower terraces of the floodplain, with emphasis on re-invigorating Floodplain Marsh species such as Moira Grass and potentially expanding its distribution on the floodplain.
- Promote the recovery of native fish populations in and around Barmah-Millewa Forest.
- Facilitate waterbird breeding success.
- Provide breeding and feeding habitat opportunities for floodplain fauna, such as waterbirds, fish, frogs and turtles.
- Enhance floodplain ecological productivity and connection with riverine foodwebs.
- Minimise summer-autumn unseasonal flooding on Floodplain Marsh plains.

A range of priority water management actions have been identified by this proposal under various water resource scenarios to achieve these aims, being:

A. **Translucent regulators**: Continue the translucent regulator strategy where forest regulators will be open in winter-spring and then closed by mid-December.

B. **Murray cod breeding:** Maintain flow within the main river channel at or above 8500 ML/day in late August through to December to support Murray cod nesting, survival and dispersal.

C. **Perch spawning pulses**: Provide flow variability within the main river channel in mid-October through to December to encourage the spawning of native fish species, primarily Silver Perch.

D. **Critical drought refuge**: Maintain critical drought refuge areas within Barmah-Millewa waterways, without return flow connectivity to the river system.

E. **General drought refuge**: Maintain general drought refuge areas within Barmah-Millewa waterways, with return flow connectivity to the river system.

F. **Waterbird breeding (dry)**: Sustain a waterbird (colonial-nesting species and bitterns) breeding event in Reed Beds Swamp or Moira Lake or Boals Deadwoods if a breeding event initiates following natural flooding and other required cues.

G. **Waterbird breeding (moderate/near average):** As per Action F but with both Barmah AND Millewa wetlands.

H. **Waterbird breeding (wet):** As per Action G but with additional wetlands

I. **Floodplain Marsh**: Build on natural flow cues to enhance conditions to promote growth of Floodplain Marsh vegetation species (including Moira Grass) on treeless plains in Millewa Forest (given that it is Millewa Forest's turn under annual-alternating flood strategy with Barmah Forest).

J. **Autumn-winter perennial flows:** Maintain river releases from Yarrawonga above 4,000 ML/d in autumn-winter for large-bodied native in perennially flowing habitats but exit (or attempt to exit) the seasonal habitat when flows cease.

The strategies are mostly tiered under water resource scenarios such that higher-level floodplain inundation events negate the need for lower floodplain watering actions.

Risks that are rated 'high' or above:

No major delivery or external flooding risks are foreseen with the proposed watering strategy. Flow constraints in the Murray River below Yarrawonga are in place to prevent flooding of private land access on the Bullatale Creek system in NSW. More detailed consideration of available environmental water volumes and natural triggers will be made prior to water release to ensure greatest chance of achieving target environmental outcomes. Reaching the goals outlined in this strategy will be largely dependent upon the provision of requested flow volumes from the environmental water holders in addition to natural flood events.

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Glossary and acronyms

Bankfull - carrying capacity of the stream before spilling out onto adjacent land

Baseflow - low flows sufficient to maintain fish passage, water quality, and pool and riffle habitats

Catchment management authority (CMA) - statutory authorities established to manage regional and catchment planning, waterways, floodplains, salinity and water quality

Channel - that part of a river where water flows at some time and includes the bed and banks, taken to mean the whole of the depression in which the water flows before it rises sufficiently to spill over onto adjacent lands as flood water

Commonwealth Environmental Water Office (CEWO) - (part of the Department of the Environment) holds and manages the water entitlements purchased through the Restoring the Balance water recovery program

CMA - catchment management authority

Department of Environment, Land, Water and Planning (DELWP) – Victorian government department responsible for protecting the environment, responding to climate change and supporting sustainable population growth

DO - dissolved oxygen level of creek water

Environmental flow regime - the timing, frequency, duration and magnitude of flows for the environment

Environmental flow study - a scientific study of the flow requirements of a particular basin's river and wetlands systems used to inform decisions on the management and allocation of water resources

Environmental water entitlement - an entitlement to water to achieve environmental objectives in waterways (could be an environmental entitlement, environmental bulk entitlement, water share, Section 51 license or supply agreement)

Flow - movement downstream of water confined in the channel. The term lotic applies to flowing or moving water

Flow component - components of a river system's flow regime that can be described by timing, seasonality, frequency and duration (for example, cease to flow and overbank flows)

Flow regime - pattern of seasonal flow variations in any one year, usually consisting of periods of low flow during summer-autumn then high flows during winter-spring

Freshes - flows that produce a substantial rise in river height for a short period, but do not overtop the river bank. Freshes help maintain water quality and serve as life cycle cues for fish

GB CMA - Goulburn Broken Catchment Management Authority

Geomorphology (fluvial) - the physical interaction of flowing water and the natural channels of rivers including erosion and sedimentation

Gigalitre (GL) - one billion (1,000,000,000) liters

GMW – Goulburn-Murray Rural Water Corporation, trading as Goulburn-Murray Water

High flows - high flow within channel capacity. High flows allow full connection between all habitats in the river, which is important to fish passage during migration

High reliability entitlement - legally recognised, secure entitlement to a defined share of water, as governed by the reserve policy (full allocations are expected in most years)

Instream - refers to that area of a waterway below the surface of the water

Inter-Valley Transfers (IVT) - means bulk transfers of water from the Goulburn water

supply system to supply water users in the Murray water supply system

Low reliability entitlement - legally recognised, secure entitlement to a defined share of water, as governed by the reserve policy (full allocations are expected only in some years)

Macroinvertebrates - aquatic invertebrates whose body length usually exceeds 1 mm (included insects, crustacean, aquatic worms and aquatic snails)

Macrophytes - an aquatic plant that grows in or near water and is emergent, submergent, or floating

Megalitre (ML) - one million (1,000,000) litres

MDBA – Murray-Darling Basin Authority

Overbank flow - flood flows that overtop the banks and spill onto the floodplain

Passing flow - water released out of storages to operate river and distribution systems (to deliver water to end users), provide for riparian rights and maintain environmental values and other community benefits

Planktonic algae - floating microscopic plants that are an important food source for aquatic fauna

Pool - a significantly deeper area in the bed of a river

Reach - a length of stream that is reasonably uniform with respect to geomorphology, flow and ecology

Riffle - a stream section with fast and turbulent flow over a pebble bed with protruding rocks (characterized by a broken water surface)

Riparian vegetation - vegetation growing on the water line, up the bank or along the very top of the bank. It is the vegetation which has the most direct effect on instream biota.

Seasonal allocation - the volume of water allocated to a water share in a given season, expressed as a percentage of total entitlement volume

The Living Murray (TLM) - an intergovernmental program, which holds an average of 500,000 ML of environmental water per year, for use at six icon sites along the River Murray

Unregulated entitlement - an entitlement to water declared during periods of unregulated flow in a river system, that is, flows that are unable to be captured in storages

Victorian Environmental Flow Monitoring and Assessment Program (VEFMAP) - assesses the effectiveness of environmental flows in delivering ecological outcomes

Victorian Environmental Water Holder (VEWH) - an independent statutory body responsible for holding and managing Victorian environmental water entitlements and allocations (Victorian Water Holdings)

Water entitlement - the right to a volume of water that can (usually) be stored in reservoirs and taken and used under specific conditions

Water Holdings - environmental water entitlements held by the Victorian Environmental Water Holder

Waterway manager - agency responsible for the environmental management of waterways (includes catchment management authorities and Melbourne Water)

Waterways - can include rivers, wetlands, creeks, floodplains and estuaries

1 Introduction

This document outlines the seasonal watering proposal for Barmah-Millewa Forest in the 2022-23 financial year, as required by the Victorian Environmental Water Holder (VEWH) for all Victorian wetland sites seeking environmental water under section 192A of the Water Act 1989. This significant wetland site is also one of six *The Living Murray* "Icon Sites" and as such is required to include the water proposal details to be populated on a template provided by the Southern Connected Basin Environmental Watering Committee (SCBEWC). This is included as an addendum to this document and has been jointly prepared by the Goulburn Broken Catchment Management Authority (GB CMA) and the NSW Department of Planning, Industry and Environment (DPIE) given the cross-border location of the Barmah (Victoria) and Millewa (NSW) floodplain forest.

This seasonal watering proposal will be used by VEWH to inform the development of the Victorian Seasonal Watering Plan 2022-23 that outlines the full scope of state-wide priorities for the use of water holdings in 2022-23. This proposal will also be used to inform The Living Murray (TLM), Commonwealth Environmental Water Office (CEWO) and NSW DPIE annual environmental watering priorities.

Environmental objectives and flow recommendations for Barmah-Millewa Forest are found in the Barmah-Millewa Environmental Water Management Plan (MDBA 2012) and Barmah-Millewa Ecological Operating Strategy (GB CMA 2015). This is underpinned by the Barmah Forest Strategic Action Plan (PV 2018) and the Joint Management Plan for Barmah National Park (YYTOLMB 2020).

Water Management Area (WMA) locations mentioned in this report are shown in Figure 1.

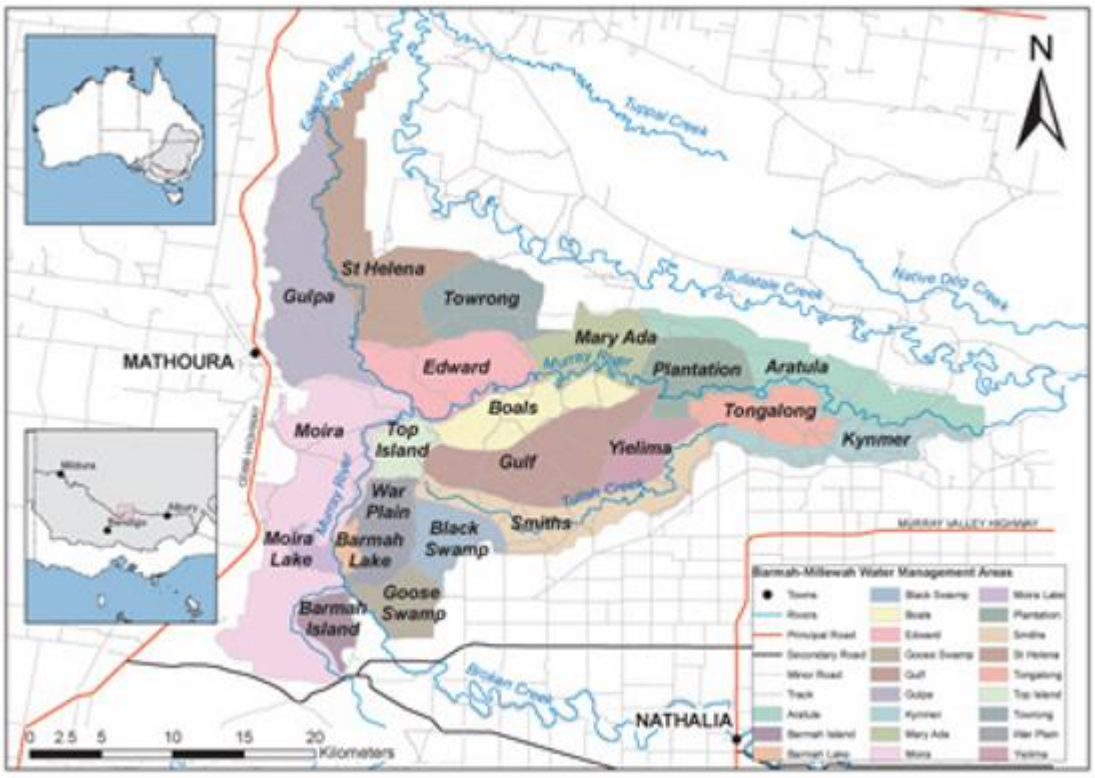


Figure 1: Barmah–Millewa water management area boundaries (source: MDBA 2012)

2 Engagement

Goulburn Broken CMA has undertaken the following stakeholder engagement during the development of this 2022-23 seasonal watering proposal. NSW DPE undertakes engagement in the development of the watering proposal for the Millewa component in NSW which is not included in the table below (Table 1).

Goulburn Broken CMA undertakes consultation on environmental water management through a structured process with key stakeholders: Yorta Yorta NAC, Goulburn-Murray Water (G-MW), Parks Victoria (PV), VEWH and the Goulburn Broken Wetlands Advisory Group (WAG). Separate consultation exists directly with NSW DPE representatives and the Murray-Darling Basin Authority (MDBA) through TLM.

Active water management planning during watering or natural food events occurs with a diverse range of government stakeholders via the Barmah-Millewa Operations Advisory Group (BM OAG). This is achieved via frequent teleconferences (usually held weekly during active events in late-winter through to early-summer, and less often outside of this core period) in addition to teleconferences of the broader Murray OAG when required. Information then passes through the Southern Connected Basin Environmental Watering Committee (SCBEWC) which coordinates the River Murray Channel Delivery Plan, as overseen by MDBA.

Presentations are sometimes also given to special interest groups upon request (e.g., University of the Third Age, Rotary, etc). Information is also given to the Barmah Forest Heritage and Information Centre (public information centre located in Nathalia township), usually by direct visitation after fieldtrips or otherwise via telephone to inform counter staff of active water management activities and current environmental outcomes (and to field questions that they may have been receiving from the public).

Table 1: Engagement on seasonal watering proposal

Category	Stakeholder(s)	IAP2 level	Engagement methods	Engagement purpose
Community and environment groups	Goulburn Broken Wetland Advisory Group members	Invole	Goulburn Broken Wetland Advisory Group meeting 24 February 2022 Direct engagement	Seek feedback on environmental water priorities for 2022-23.
Government agencies	G-MW VEWH CEWH Parks Victoria Moira Shire	Collaborate	Goulburn Broken Wetland Advisory Group meeting 24 February 2022 Direct engagement	Seek input to development of the proposal. Understand any delivery constraints or issues and plan for environmental water delivery in 2022-23.
Landholders/farmers	None in Victoria (NSW consults with Bullatale Creek landholders)	Consult	NSW contacts key stakeholder representatives	NSW consults on possibility to exceed 15,000 ML/d river flow downstream of Yarrawonga in August and September and to assure of plans not exceeding this level with e-water releases at other times. Relevance to Barmah due to single floodplain shared with Millewa in NSW. No impacts occur to landholders on Victorian side of river.
Recreational Users	Goulburn Broken Wetland Advisory Group members	Involve	Goulburn Broken Wetland Advisory Group meeting 24 February 2022 Direct engagement	Seek feedback on environmental water priorities for 2022-23.
Traditional Owners	Yorta Yorta Nation Aboriginal Corporation	Involve	Direct engagement – meeting on 2 March 2022	Identify Aboriginal values and uses of the creeks. Seek feedback on environmental water priorities for 2022-23.
Local businesses	None	-	-	-

3 Aboriginal cultural values and uses of waterways

Aboriginal cultural values and uses of waterways in Barmah Forest are outlined in the Joint Management Plan for Barmah National Park (YYTOLMB 2020). Indigenous values are more than "stones and bones"; it is an inherent connection to land (woka) and water (walla) and caring for Country. The Joint Management Plan lists the "Restoring the health of Country, especially the condition of Barmah's internationally significant Ramsar wetlands is the most important focus of the plan" and highlights the importance of "improving the health of Country in the park with priority on restoring Moira grasslands and marshes through a better water regime".

The actions described in this Seasonal Watering Proposal aim to protect and enhance the environmental values of Country, and in doing so assist with protection of cultural values (Table 2). The Living Murray program supports an Indigenous Facilitator position within Yorta Yorta Nations Aboriginal Corporation, and that person has direct input into water management planning and actions as well as research and monitoring proposals and activities.

Table 2: Traditional owner values and alignment with potential watering actions

River/Wetland	Traditional owner Group	Values / uses / objectives / opportunities	Alignment with potential watering action
Dhungalla (Murray River) / Pama National Park (Barmah National Park)	Yorta Yorta Nations Aboriginal Corporation	Supporting the health of cultural values and landscapes - protecting intangible cultural heritage and valued species, traditional food and medicine plants Actively fulfilling Caring for Country responsibilities - investigating more natural water regimes to degraded significant sites, rehabilitation of native habitat conditions	The Seasonal Watering Proposal aims to enhance winter-spring flooding and minimise unseasonal summer-autumn flooding to reflect the natural flood regime which in turn will best support the protection of aboriginal values. *NB: This table has yet to benefit with specific input by YYNAC at the time of writing.*

4 Social, recreational, and economic values and uses of waterways

Dyack *et al.* (2007) assessed the non-market recreational values at Barmah Forest as part of a larger program of research in the Water for a Healthy Country National Research Flagship about the wider range of uses and values of water in the Murray region. Data for the project was collected by asking visitors on-site to participate in a questionnaire in January 2006 where over 95% of recreational visitors were approached agreed to participate.

The report found the most important reason for visiting Barmah Forest was (in descending order):

1. Relaxing
2. Catching up with friends
3. Fishing
4. Being close to water

5. Having quality time with family
6. Water activities
7. Getting close to nature
8. Good for my wellbeing
9. Enjoying this part of the Murray River
10. Outdoor activities
11. Area offers best combination of activities
12. Visiting special spots

The most important activities were (in descending order):

1. Camping
2. Relaxing
3. Swimming
4. Fishing from shore
5. Boating
6. Fishing from boat
7. Other
8. Water skiing / jet skiing
9. Bushwalking
10. Sightseeing
11. Picnicking
12. Four-wheel driving
13. Bird watching
14. Canoeing / kayaking
15. Aboriginal cultural heritage
16. Nature study

The report found, in general, respondents showed an understanding of the link between environmental condition, management and the quality of their recreational experience but they did not always rank recreation as the top priority when it comes to management goals.

Thus visitors (at least those at the time of the above survey) valued a range of passive and active recreational pursuits at Barmah Forest, most if not all can be enhanced with the current suite of e-water management actions being proposed. There have not been any requests for watering actions to support particular community values.

Table 3 outlines the broader shared benefits achieved from the delivery of environmental water to Barmah-Millewa Forest.

Table 3: Social, recreational, and economic shared benefits of environmental water in 2022-23

Waterway	Shared benefit	Beneficiary	Description
Murray River and distributary channels within Barmah-Millewa Forest	Economic	Consumptive water users – GMW irrigators and diverters	Environmental flows improve water quality, reduces blackwater risk and Blue Green Algal blooms which reduces the treatment costs for downstream urban water authorities and reduces operational risk. Water diversion through Barmah-Millewa Forest (when required for environmental purposes) can alleviate some Choke channel capacity constraints for downstream irrigation and urban water demands.
As above	Recreational Amenity	Broader community, local residents, visitors (day or camping), anglers, bird watchers, photographers, kayakers/canoers.	Environmental water improves vegetation and water quality and consequently provides an attractive area for day visitors and campers with enhanced active (e.g., fishing, boating) and passive (e.g., birdwatching) recreational pursuits. Environmental water improves the local environment and increases species richness in the riparian and floodplain area to retain or enhance natural assets that can be enjoyed by everyone and encourages community conservation and outdoor activities.
As above	Recreational Economic	Broader community Anglers	Using environmental water to provide fish spawning, migration, passage and habitat enhances native fish populations for recreational benefit. The benefits are extended to other waterways in the entire southern connected Murray Darling Basin.

5 Seasonal Review (2021-22)

5.1 Ecological and Hydrological Review

The 2021-22 year was generally characterised by average weather conditions (Figure 2; current to 19th March 2022), despite La Nina conditions which are usually associated with wetter than average conditions, but the year did experience some low to mid-level natural flooding that was augmented by e-water management (Figure 3).

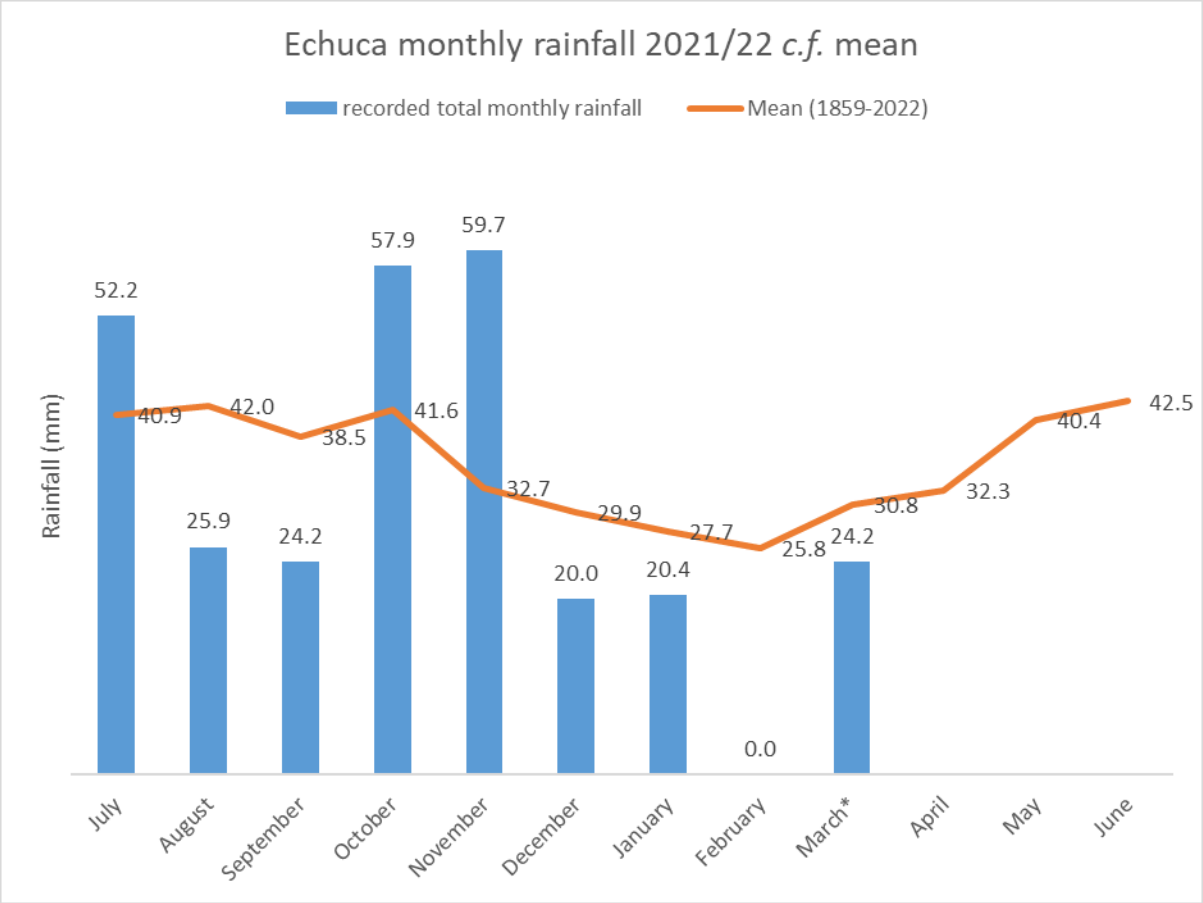


Figure 2: Monthly rainfall totals of Echuca Aerodrome (Station 080015) in 2021-22 compared with the long-term average (source: BoM 2022a & b) – current to 19/03/2022

Figure 3 presents a hydrograph of the Murray River downstream of Yarrawonga for the 2021-22 financial year (current to 17th March 2021 = the time of writing) showing the period of managed flows and flooding in Barmah-Millewa Forest. The key features of this hydrograph and of environmental watering in 2021-22 are:

- River flow from Yarrawonga fell from short natural flood peak of 12,5000ML/d on 01/07/2021 followed by a larger natural flood peak of 27,000ML/d on 21/07/2021 and 30,000ML/d on 03/08/2021 (the first would have been 60,000ML/d under natural conditions, while the second peak would have been 80,000ML/d).
- Translucent Regulator operations occurred in August and September where regulators were open irrespective of river levels to divert some water through both Barmah and Millewa forests until environmental water releases commenced in mid-October. [NB: water losses to the forest are underpinned by environmental water accounts]
- E-water releases then maintained the river below Yarrawonga between 12,000 - 15,000ML/d until a larger natural flood peak commenced in early September (45,000ML/d) which was then followed by a slightly smaller peak in late-September/early-October (40,000ML/d).
- E-water releases again resumed once river releases started to fall below 15,000ML/d to maintain the releases between 14,500 to 15,000ML/d from late-October until 10 November when pre-releases for air-space management from Hume recommenced in anticipation of forecast rainfall; widespread rain did subsequently occur and hence River Operations passed the natural flows.

- Flows were then reduced by 1,000ML/d using e-water for the difference with what River Management Operators (RMO) would have otherwise released until back to channel capacity. Some e-water had continued to be used to support losses associated with regulator manipulations for fish-exit monitoring, and into Boals Deadwoods for nesting waterbirds but substituted for RMO flows when these were available.
- Mid-January and early-February then saw further rain-rejection and air-space management events following high rainfall totals to cause a temporary release from Yarrawonga of 17,700ML/d and 25,600ML/d respectively (all forest regulators had to be opened during this period) before recession back to channel capacity of 8,500ML/d.
- E-water diversion into Boals Deadwoods continued for 2.5 months until 01/03/2022 when its regulator was closed following the successful completion of ibis nesting (431 nests; 79% AWI, 19% SNI).
- A blackwater event followed the summer natural flood pulses through Barmah Forest, however no fish deaths were found to have occurred.
- The lower floodplain was inundated for seven months given successive natural flood peaks spanning this period.
- Approximately 55% of Barmah Forest and 55% of Millewa Forest floodplain was inundated from the peak spring natural flood event.
- Under modelled Natural Conditions (i.e., without regulation), the river would have peaked at 78,000MLl/d in August and 83,000ML/d in September and hence would have inundated all the active floodplain.
- Staged closure of regulators occurred at the end of flood peaks in attempt to permit fish to exit the waterways through the regulators before they were fully closed. This work was monitored by an Intervention Monitoring project where acoustic-tagged fish were known to be behind the regulators. Results are yet to be analysed. To gauge success of the strategy.
- Flows were generally equally shared between Barmah and Millewa forests, with slight bias to maintaining all Millewa Forest regulators fully open, especially when targeting the exit of fish at the conclusion of the regulators having to be closed.

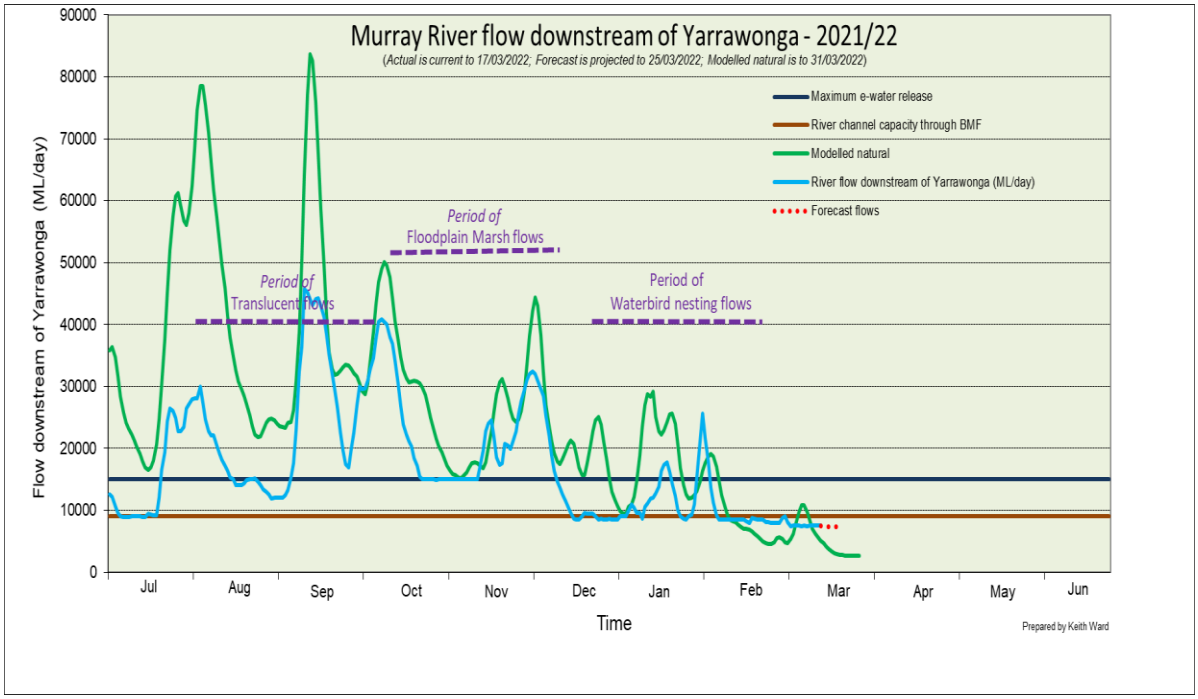


Figure 3: Hydrograph showing actual flow in the Murray River downstream of Yarrawonga in 2021-22 (current to 17/03/2022).

Despite the duration of the flooding representing that which used to occur more frequently under natural conditions (Abel *et al*. 2006), the magnitude of the flood was average for recent years but low compared to historic conditions (Figure 4).

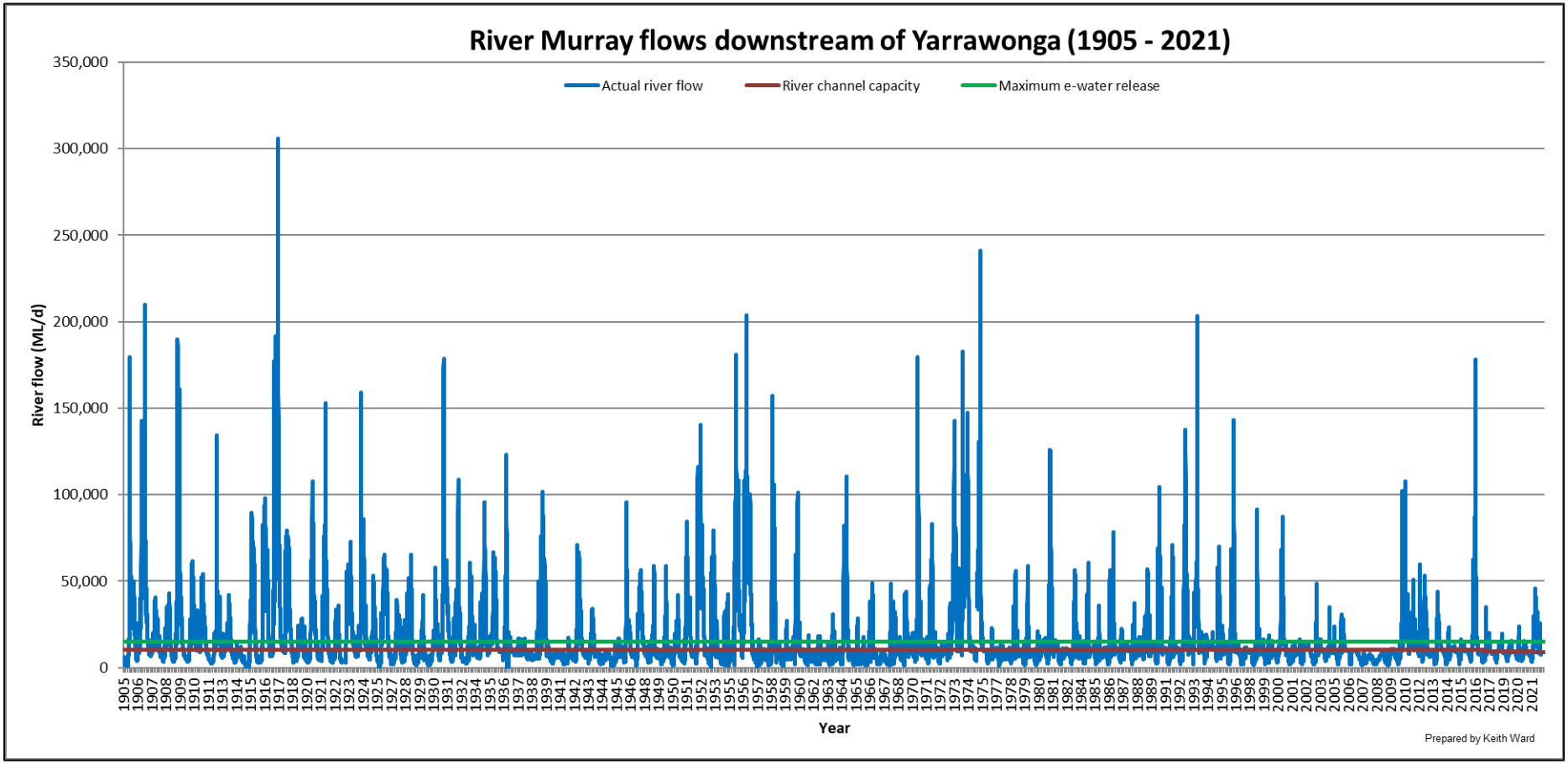


Figure 4: Murray River flow downstream of Yarrawonga (= reach through Barmah-Millewa Forest) for past 117 years, showing the recent past 5 years have experienced low to very low-level flooding by comparison with most previous years (flow data from MDBA 2022).

Figure 5 shows the extent of Barmah-Millewa floodplain inundation following the larger of the various natural flood peaks to have occurred during spring 2021 (briefly peaking at 45,700ML/day downstream of Yarrawonga on 11 September 2021). When compared with previous flooding over the past 23 years of records kept for the degree of flooding per water management area (as initiated by the Barmah-Millewa Forum in 1998), then this most recent year's flooding was around average despite the wetter-than-average rainfall in the upper catchment (Table 4).

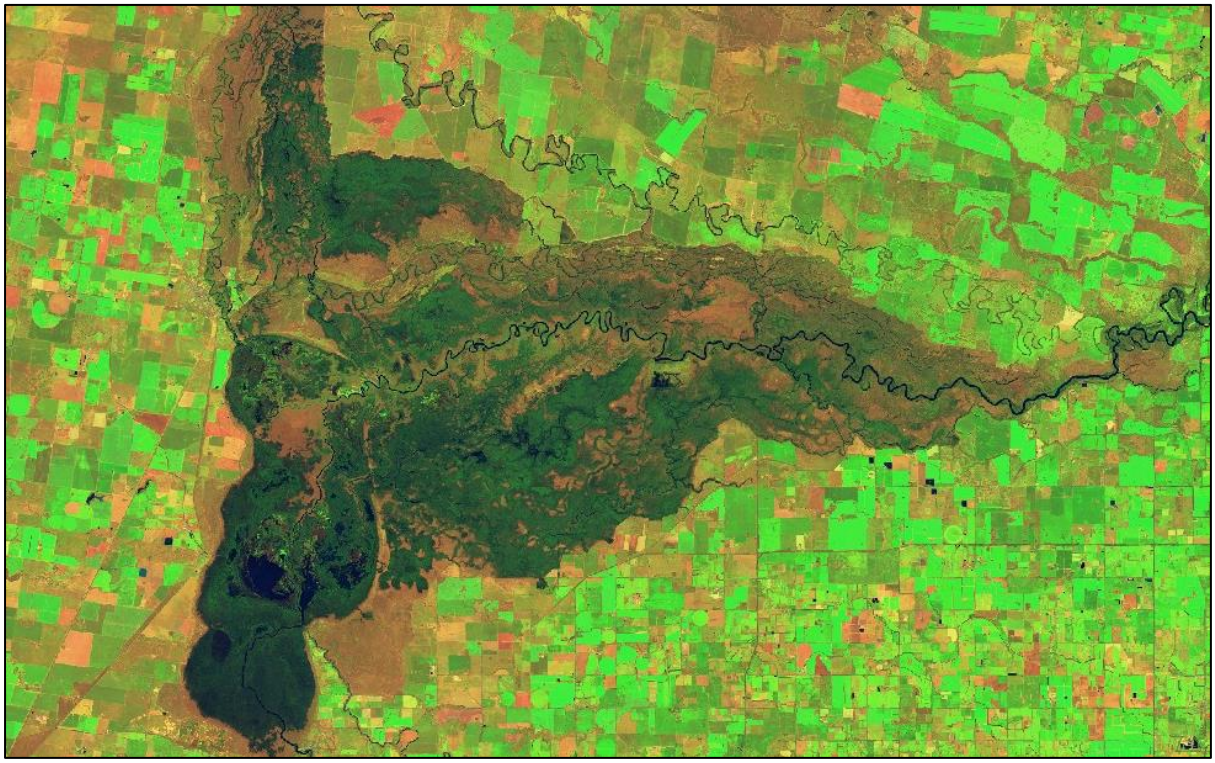


Figure 5: Colour enhanced Sentinel-2 satellite image of Barmah-Millewa Forest, taken 22 October 2021 representing nearest cloud-free image to the flood peak 42 days earlier at 45,700ML/d at Yarrawonga), showing extent of floodplain inundation (from Sentinel-hub 2021). Approximately 55% of the active floodplain (or 50% of the forest reserve) was inundated at the peak of natural flooding in spring 2021 (based on hydrodynamic modelling of 35,000ML/d for a month run; Keogh 2012).

Table 4: Barmah-Millewa Forest flood history (past 24 years), separated by "water management area" and prioritised based on WMA flood deficiency scores (adopted from Barmah-Millewa Forum 1996-2003).

	Water Management Area	Observed flooding score																								Ideal average annual	Accumulated score	Ideal score	Departure from ideal flood score	Watering priority for 2020	Ranking	Ecological outcomes/observations (*details in 2016-17 synthesis report and consultant reports*)
		1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021							
Barmah Forest sites	Kynmer Creek (A)	1	1	2	0	1	0	0	1	0	0	0	0	3	2	2	2	1	1	3	1	1	1	1	2	1.3	26	31.2	-5.2	-	13	1,4,5
	Tongalong Creek (B)	1	1	3	0	1	1	1	2	0	0	0	0	3	3	3	3	1	1	3	1	2	1	1	2	1.5	34	36.0	-2.0	-	18	1,2,4,5
	Smiths Creek (C)	3	1	3	0	1	0	0	2	0	0	0	0	3	2	2	2	1	1	3	1	2	1	1	2	1.5	31	36.0	-5.0	-	14	1,2,4,5
	Yielima (D)	2	1	3	0	0	0	0	2	0	0	0	1	3	2	2	2	1	1	3	2	2	1	1	2	1.5	31	36.0	-5.0	-	14	1,4,5
	Black Swamp (E)	2	1	3	0	0	0	0	1	0	0	0	0	3	2	2	2	1	0	3	1	2	0	0	1	1.6	24	38.4	-14.4	Priority	6	1
	Gulf Creek (F)	2	1	3	0	2	1	1	3	0	0	1	1	3	3	3	3	1	1	3	2	2	1	1	2	1.9	40	45.6	-5.6	-	12	1,2,3,4,5
	Boals Deadwood (G)	2	1	2	0	1	1	1	3	0	0	0	1	3	3	3	3	2	2	3	2	2	2	2	2	1.9	41	45.6	-4.6	-	16	1,3,4
	Top Island (H1)	2	1	3	0	1	1	1	3	0	0	0	0	3	2	2	2	1	1	3	2	2	1	1	2	1.9	34	45.6	-11.6	Priority	8	1,3,4
	Steamer/War Plain (H2)	2	1	3	0	2	2	2	3	1	0	0	1	3	3	3	3	2	2	3	2	2	1	1	2	2.0	44	48.0	-4.0	-	17	1,2,3,4,5
	Goose Swamp (H3)	1	1	3	0	1	1	0	0	0	0	0	0	3	2	2	2	1	0	3	1	2	0	0	0	1.6	23	38.4	-15.4	Priority	5	1,3,4
	Barmah Island (H4)	2	1	3	0	2	2	2	1	0	0	0	0	3	2	2	2	1	1	3	2	2	1	1	2	2.0	35	48.0	-13.0	Priority	7	1,2,3,4,5
Millewa Forest sites	Aratula Creek (J)	3	0	3	0	0	0	0	1	0	0	0	0	3	2	2	2	1	1	3	1	1	1	1	2	1.5	27	36.0	-9.0	-	9	1,4,5
	Plantation (L)	2	0	3	0	0	1	0	1	0	0	0	0	3	2	2	2	1	1	3	1	1	1	1	1	2.0	26	48.0	-22.0	Priority	1	1,3,4
	Mary Ada (M)	3	0	3	0	0	1	1	2	0	0	0	0	3	3	3	3	1	2	3	2	1	2	2	2	1.9	37	45.6	-8.6	-	10	1,2,3,4,5
	Edward River (N)	3	1	3	0	0	1	1	2	0	0	0	0	3	3	3	3	1	2	3	2	1	2	2	2	2.3	38	55.2	-17.2	Priority	3	1,2,3,4,5
	Towrong Creek (P)	3	0	3	0	0	0	1	2	0	0	0	2	3	2	2	2	1	1	3	2	1	2	2	2	1.4	34	33.6	0.4	-	19	1,2,3,4,5
	St Helena Swamp (Q)	2	1	3	0	0	1	1	2	0	0	0	0	3	3	3	3	1	2	3	2	1	2	2	2	2.2	37	52.8	-15.8	Priority	4	1,2,3,4,5
	Gulpa Creek (R)	2	1	3	0	0	1	2	1	0	0	0	0	3	3	3	3	2	1	3	2	0	1	1	1	2.2	33	52.8	-19.8	Priority	2	1,2,3,4,5
	Moira Lake (S)	2	1	3	0	2	1	2	2	1	0	0	0	3	3	3	3	2	2	3	2	1	2	2	2	2.0	42	48.0	-6.0	-	11	1,2,3,4,5

Flood scores:

0 "no flooding the WMA"

1 "some flooding the WMA"

2 "lot of flooding"

3 "completely flooded"

Based on the proportion of wetlands and Site Quality timber in each WMA and their desirable flooding frequencies: Wetlands = 10 years out of 10, SQ1 = 8 years out of 10, SQ2 = 5 years out of 10, and SQ3 = 3 years out of 10.

1 = Native vegetation impovements

2 = Native fish benefits

3 = Native waterbird benefits

4 = Frog/turtle benefits

5 = Water quality benefits

The spring 2021 water delivery between successive higher natural flood peaks was successful in achieving priority watering actions under a "moderate to wet" scenario of attempting to meet *Floodplain Marsh* requirements and waterbird nesting outcomes. Perch spawning pulses and consolidating some previous successful environmental water outcomes was also achieved (Table 5).

Table 5: Summary of last 13 years of flooding and associated outcomes at Barmah-Millewa Forest.

Year	Forest flooding
2009-10	• Drought conditions prevailed with flows not exceeding channel capacity. • 18 GL of environmental water was delivered for recovery and maintenance of wetland vegetation and habitat for bird breeding and foraging • No breeding of waterbirds took place this year • An estimated 15% of the floodplain was inundated.
2010-11	• Natural major flooding returned with peaks in excess of 100,000 ML/day (10 times the capacity of the Barmah Choke) occurring in September and December of 2010. Unusually, the flooding persisted for the entire year over much of the floodplain with significant late summer / early autumn flooding. • 428 GL of environmental water was delivered to Barmah-Millewa Forest. The environmental water was delivered to maintain flows at or above channel capacity, preventing the draining of wetlands and the potential for nest abandonment by colonially nesting waterbirds, as well as maintaining ideal flood depth and duration for wetland vegetation such as Moira Grass. • An estimated 90% of the floodplain was inundated
2011-12	• Late winter and early spring natural flood events peaking at 50,000 ML/d in August were followed by a slightly drier than forecast conditions for the remainder of spring. Following the completion of colonial waterbird breeding, wetlands were entering a desirable drying cycle, before a highly unusual March flood event re-flooded the majority of the floodplain after sharply peaking at 57,000 ML/d downstream of Yarrawonga. • A total of 425 GL of environmental water was delivered to maintain flows at or above channel capacity between natural flood peaks in spring and summer. This was to maintain water under colonially nesting waterbirds. A pulse was delivered in late November – early December for native fish spawning, • An estimated 65% of the floodplain was inundated.
2012-13	• An early winter natural flood event extended through to mid-October, briefly peaking at 53,000 ML/d in July and 41,000 ML/d in August but was then followed by a drier than average conditions for the remainder of spring. The lower floodplain region experienced a desirable dry phase after largely being inundated for the previous 2.5 years, although completion of waterbird breeding required some targeted release of environmental water. • 3 GL of The Living Murray environmental water was delivered to Boals Deadwoods wetland between 17 November 2012 and 14 January 2013. This water successfully maintained shallow flooding beneath colonially nesting waterbirds (White Ibis, Straw-necked Ibis and Royal Spoonbill). • 11.8 GL of environmental water was delivered to Reed Beds Swamp in Millewa Forest. • An estimated 60% of the floodplain was inundated.
2013-14	• Natural flood peaks occurred in July, August and September, peaking at 44,000 ML/day. The rate of flood recession in October was slowed by maintaining the river at 18,000 ML/day for two weeks at a time when levels would have otherwise dropped to only 8,000 ML/day under regulated conditions with no environmental water release. This had the added benefit of trailing a threshold concern of flooding private property in NSW. Flows were then maintained at 15,000 ML/day in the River Murray downstream of Yarrawonga until the end of November. • Perch spawning was induced by causing a four-day reduction in flows by 400 ML/day from Yarrawonga in mid-November inducing temporary flow variability without exceeding 15,000 ML/day maximum flow threshold. • Total environmental water delivered was 371.3 GL • An estimated 60% of the floodplain was inundated.
2014-15	• Two natural flood peaks occurred in July, briefly peaking at 20,600 ML/day and 23,600 ML/day, followed by brief periods of overbank flows in August (11,600 ML/day), November (12,100 ML/day) and January (12,300 ML/day). The rate of flood recession in late-July was rapid, although briefly slowed by the early-August fresh. • The November fresh created flow variability at a time of year when Perch species are known to use increasing flows as a cue for spawning and as such no environmental water was delivered. However Golden Perch were found not to have spawned on this event. It is now understood that this event occurred too late in the season when water temperatures were too high, spawning cues will now be delivered earlier in the October/November period in future. • No environmental water was released for Barmah-Millewa Forest in 2014-15. • An estimated 25% of the floodplain was inundated in July/August.

Year	Forest flooding
2015-16	• Low rainfall was experienced throughout much of the year meaning the areas of the floodplain that weren't flooded stayed very dry • Three small natural flood peaks occurred in early August (16,313 ML/d), early September (15,254 ML/d) and late October (13,986 ML/d) • An estimated 17% of the floodplain was inundated. • Environmental water was released between July and September to maintain depth and duration of flooding on low-lying wetlands and grassy plains. Most of the environmental water was directed to Millewa Forest. • Environmental water was also delivered to support colonial waterbird breeding in Boals Deadwoods and Reed Beds Swamp. • Approximately 1,500 pairs of Australian White Ibis and Straw-necked Ibis, 220 pairs of Royal Spoonbills, 100 pairs of Eastern Great Egrets and multiple colonies of cormorants were observed breeding in Barmah-Millewa Forest. Australasian Bitterns were also heard calling throughout the forest.
2016-17	• Above average rainfall throughout winter and spring caused near continuous overbank flows and Hume Reservoir to spill. • Three large natural flood peaks occurred in early August (62,664 ML/d), late September (87,200ML/d) and early October (179,285 ML/d). • An estimated 98% of the Barmah-Millewa floodplain was inundated. • Environmental water was released in December 2016 to slow the rate of flood recession from the floodplain following rapid recession of the final natural flood peak, for the benefit of Moira Grass plains that had commenced flowering. Most of the environmental water was directed to Barmah Forest under the annual-alternating EWA arrangement with Millewa Forest. • Environmental water was also delivered to support colonial waterbird breeding in Boals Deadwoods and Reed Beds Swamp from December through to mid-February. • Excellent waterbird breeding conditions were evident in Barmah Forest this year with approximately 1,000 pair of Australian White Ibis, 1,000 pair of Straw-necked Ibis, 60 pair of Royal Spoonbill, 2 pair Yellow-billed Spoonbill, 4,000 pair of Rufous Night-heron, 100 pair of Eastern Great Egret, 20 pair Intermediate Egret, 500 Little Pied Cormorant, 300 Little Black Cormorant, 4 Great Cormorant, 2 Darter and numerous waterfowl including many hundreds of pair of Grey Teal, Black Duck and dozens of Black Swan, were observed breeding in Barmah-Millewa Forest. Australasian Bittern and Little Bittern were also heard calling within most reed-dominated wetlands throughout the forest. A variety of other wetland birds were also recorded utilising or breeding in the forest. Millewa Forest recorded similar species in similar numbers (species and numbers awaiting confirmation at the time of writing), although Straw-necked Ibis counts in particular were much larger. • Moira Grass (*Pseudoraphis spinescens*) growth was variable, attaining lengths exceeding 4m length at most existing sites although flowering was profuse only where the grass stems were not otherwise covered in filamentous brown algae. Encouragingly, some occurrence of the species was noted from areas where it had previously disappeared, although range expansion cannot be confirmed until targeted surveys are completed.
2017-18	• Mix of above and below average rainfall throughout winter and spring caused varying flood levels throughout the forest. • Modest size natural flood peaks occurred in late August (34,928 ML/d) and early-December (18,784ML/d). • An estimated 45% of the Barmah-Millewa floodplain was inundated. • Environmental water was released in October and November 2017 to maintain Floodplain Marshland inundation following rapid recession of the first natural flood peak, for the benefit of Moira Grass plains that had commenced growing. Most of the environmental water was directed to Millewa Forest under the annual-alternating EWA arrangement with Barmah Forest. • Environmental water was also delivered to support colonial waterbird breeding in Boals Deadwoods and Top Island from December through to January but was halted when monitoring had shown waterbird nesting had prematurely abandoned due to a high wind event (egrets at Top Island) and predation of ibis/spoonbill nests at Boals Deadwoods. • Approximately 5 pair Yellow-billed Spoonbill, 300 pair of Rufous Night-heron, 30 pair of Eastern Great Egret, 300 Little Pied Cormorant and 100 Little Black Cormorant, plus numerous waterfowl including many hundreds of pair of Grey Teal, Black Duck and dozens of Black Swan, were observed breeding in Barmah-Millewa Forest. Australasian Bittern and Little Bittern were also heard calling within most reed-dominated wetlands throughout the forest. A variety of other wetland birds were also recorded utilising or breeding in the forest. Millewa Forest recorded similar species, although Straw-necked Ibis, White Ibis and Royal Spoonbill breeding persisted in Reed Beds Swamp through to successful fledging. • Moira Grass (*Pseudoraphis spinescens*) growth was relatively high this year with abundant flowering observed.
2018-19	• Well-below average rainfall throughout winter, spring and summer (except for one large event in December) to cause drought conditions in the forest where not otherwise inundated with managed flows. • Two small natural flood peaks occurred in early-September (13,000 ML/d) and mid-December (19,500ML/d). • Translucent Regulator operations in July and August (underpinned by environmental water accounts) progressively diverted some water through both Barmah and Millewa forests until River Operations water was required to be diverted solely through Barmah Forest to exceed Choke capacity constraints for downstream water orders, causing sustained inundation of the low-laying Barmah floodplain between September to December.

Year	Forest flooding
	• Environmental water was released in November and December 2018 to slow the rate of flood recession from the Floodplain Marshlands following some reduced River Operations flows, for the benefit of Moira Grass plains that had commenced flowering and for downstream environmental water orders. Most of the environmental water was directed to Barmah Forest given it was the most efficient route for returning flows to the Murray River. • An estimated 30% of the Barmah floodplain was inundated. Millewa was substantially less (~5%). • Environmental water was not required in 2018-19 for colonial waterbird breeding given poor nesting response. • A colony of approximately 100 Little Pied Cormorants, 20 Little Black Cormorants, 20 Royal Spoonbill and 80 Night Herons occurred, although 30 nests of White Ibis had commenced but abandoned following flood recession as their numbers where insufficient to warrant the volume of environmental water to sustain them. Numerous waterfowl including many hundreds of pair of Grey Teal, Black Duck and dozens of Black Swan, were observed breeding in Barmah Forest. Australasian Bittern and Little Bittern were also heard calling within most reed-dominated wetlands throughout the forest. • Moira Grass (*Pseudoraphis spinescens*) growth was exceptionally good, attaining long length and profuse flowering at most sites. Encouragingly, some occurrence of the species was noted from areas where it had previously disappeared, although range expansion cannot be confirmed until targeted surveys are completed.
2019-20	• Well-below average rainfall between late-winter to early-summer caused very dry conditions in the forest where not otherwise inundated by managed e-water flows. • Two small natural flood peaks occurred in July (13,200 ML/d) and early-August (12,600ML/d), although the peaks were greatly attenuated by the time they reached Barmah-Millewa Forest. • Translucent Regulator operations in July and August (water losses to the forest were underpinned by environmental water accounts) progressively diverted some water through both Barmah and Millewa forests until e-water releases commenced mid-August until mid-October. • Initial e-water releases were made in mid-August to late-August (at 11,000ML/d) to target Floodplain Marshlands (Moira Grass plains) as a frost-protection measure after the small winter.
2020-21	• Two very small natural flood peaks occurred in mid-July (10,500 ML/d) and late-August (10,000ML/d), although the peaks were greatly attenuated by the time they reached Barmah-Millewa Forest. • Translucent Regulator operations in August and September (water losses to the forest were underpinned by environmental water accounts) progressively diverted some water through both Barmah and Millewa forests until environmental water releases commenced in early-October. • The bulk of environmental water releases were made in mid-October (at maximum permissible constraint of 15,000ML/d from Yarrawonga) to target Floodplain Marshlands (Moira Grass plains) until mid-November before tapering back to regulated river channel capacity of 9,000ML/d in mid-December. • The slow recession was to minimise the risk of fish and turtle strandings on the broader floodplain. • Flows were generally equally shared between Barmah and Millewa forests, with slight bias to maintaining all Barmah Forest regulators fully open, especially when targeting the flooding of Little Rushy Swamp. • Approximately 25% of Barmah Forest and 25% of Millewa Forest floodplain was inundated. • A relatively late-starting nesting colony of straw-necked Ibis, Australian White Ibis and Royal Spoonbill commenced in Boals Deadwoods wetland. This was then maintained with e-water releases until late-February to successfully complete the fledging of chicks (av 2 per nest) from approximately 450 nests (`325 AWI, ~100 SNI and 75 RS). This represented the first successful nesting of these species in Barmah Forest for the past 4 years. • Approximately 100 Little Pied Cormorants and 50 Little Black Cormorants also successfully nested at Harbours Lake but completed fledging by the conclusion of the main e-water event in mid-December and hence did not require any additional targeted delivery. • Only small numbers of waterfowl (primarily Grey Teal, Black Duck and some Black Swan) were observed breeding. Australasian Bittern and Little Bittern were also heard calling within most reed-dominated wetlands throughout the forest and suspected to have successfully nested. • Moira Grass (*Pseudoraphis spinescens*) growth and flowering was very good where flooded but persisted best only in the six grazing-exclusion fenced sites that the CMA had constructed within Barmah Forest. • Some minor unseasonal flooding occurred in the Gulf Creek system in mid-January and early-February caused by rotted boards on a gate of the Gulf Regulator before being repaired.
2021-22	• Five main natural flood peaks occurred in late-July to early-December, the largest briefly peaking at 46,700ML/d from Yarrawonga on 11 September 2021. • Translucent Regulator operations in August and September (water losses to the forest were underpinned by environmental water accounts) progressively diverted some water through both Barmah and Millewa forests until environmental water releases commenced in mid-October and progressively ceasing mid- to late-December. • The bulk of environmental water releases were made in mid-October to mid-November (at maximum permissible constraint of 15,000ML/d from Yarrawonga) to target Floodplain Marshlands (Moira Grass plains). Natural flooding in mid-November finished the need for most of the forest e-watering before tapering back to regulated river channel capacity of 9,000ML/d in mid-December. • Staged closure of the regulators reduced the rate of flood recession to minimise the risk of fish and turtle strandings on the broader floodplain and to trial fish-exit strategy through the regulators (results pending). • Flows were generally equally shared between Barmah and Millewa forests, with slight bias to maintaining all Millewa Forest regulators open during a broader period.

Year	Forest flooding
	• Approximately 45% of Barmah Forest and 55% of Millewa Forest floodplain was inundated (based on Keogh 2012 model runs at 35,000ML/d for a month). • A relatively late-starting nesting colony of straw-necked Ibis, Australian White Ibis and Royal Spoonbill commenced in Boals Deadwoods wetland (Barmah) and Reed Beds Swamp (Millewa). This was then maintained with e-water releases until end of February to successfully complete the fledging of chicks. Nest survey via drone by UNSW counted 431 nests in Boals Deadwoods (342 AWI + 89 SNI) and 462 nests in Reed Beds Swamp (227 AWI, 235 SNI & 91 RS), although numbers are expected to have been greater given that the survey was relatively late into the nesting period (for example, over 1400 SNI chicks were counted in Reed Beds Swamp during the same survey). Suitable water level management and lack of extreme heatwaves ensured relatively few chick mortalities this year. • Approximately 1600 Rufous Night-heron, 30 Eastern Great Egret and 70 Intermediate Egret nests occurred on the Barmah Forest side of the Murray River near Picnic Point, and a similar number (although not surveyed; general observation only) on the Millewa Forest side. For Barmah, the nesting of the white egret species represents that last known site where they continue to nest in Victoria and hence is a very significant event for these threatened species. As nesting occurred over high ground of the natural river levee, no specific e-water management was required apart from the benefits of broader floodplain inundation that occurred from natural flooding augmented with e-water flows to provide the food resource required by these wetland species. • Approximately 75 Little Pied Cormorants, 25 Little Black Cormorants and one Darter successfully nested at Harbours Lake (a site where they regularly nest) and completed fledging by the conclusion of the main e-water event in mid-December and hence did not require any additional targeted delivery. No nesting occurred at War Plain where they have also nested in previous years. • Reasonable numbers of waterfowl (primarily Grey Teal, Black Duck, Musk Duck and some Black Swan) were observed breeding. Australasian Bittern and Little Bittern were also heard calling within most reed-dominated wetlands throughout the forest and suspected to have successfully nested. • Moira Grass (*Pseudoraphis spinescens*) growth and flowering was very good in flooded wetlands where the species retains its presence but in Barmah Forest persisted best only in the six grazing-exclusion fenced sites that the CMA had constructed in recent years. • Some unseasonal flooding occurred in mid-January (peaking at 17,600 ML/d) and early-February (peaking at 25,600 ML/d), caused by high rainfall totals in the upper catchment. As the peaks exceeded the level that could be preferentially managed into Millewa Forest (given that the 2020-21 year was scheduled to be the year that water management was to bias that side of the river) then both Barmah and Millewa forest regulators were all fully opened during those flows. As such, much of the lower B-M floodplain was reflooded during summer which resulted in some hypoxic blackwater to develop and return to the Murray and Edwards rivers, although no fish death incidents occurred.

5.2 Shared Benefits review

The shared benefits of the 2021-22 flooding events are summarised in Table 6. These have been categorised as follows:

A = High visitor exposure
B = Media outcome
C = Improved boating
D = Improved fishing
E = Improved birdwatching.

Generally, sites located along the major rivers had high visitor exposure where increased flow associated with EWA management could be seen as a benefit where extensive natural flooding did not prevent access. Camping, boating and fishing remain the major attraction to visitors, although birdwatching, mountain bike riding, canoeing and "brumby watching" are also important to many visitors. Parks Victoria maintained media releases on their website outlining track access conditions.

Many beehives had been relocated to Barmah National Park after alpine fires. Forest flooding would have benefited flower rates of Red Gums which in turn would have benefitted the apiarists.

The Kingfisher tourist boat would have benefitted from broader forest flooding via attracting increased birdlife as an attraction to the environmental education cruise. Although the boat is no longer permitted to ply Barmah Lake and associated lower waterways, it retains its Murray River route through the Choke. Covid-travel restrictions had hit this business hard through decreased

patronage and hence the publicity of the wetlands receiving some flooding assisted towards fostering an increase in interest for visitors to the area (Bernita Cox pers. comm. and Facebook website).

Substantial return flows to the river following floodplain inundation were re-credited to river operations and environmental water accounts as appropriate. These flows were reallocated to downstream irrigation/domestic and environmental water use.

These same opportunities exist for the similar watering proposal for the forthcoming year (2022-23).

Table 6: Summary of shared benefits opportunities associated with the 2021-22 Barmah-Millewa Seasonal Watering Proposal.

Who	Shared benefit
Community members who go camping in Barmah Forest	Floodplain watering improves aesthetics through presence of water, improvements to vegetation condition, increases birdwatching opportunities and maintains waterways for fishing and canoeing.
Tourism Industry	Floodplain watering increases bird activity that in turn makes for a more attractive tourist experience on-board the Kingfisher boat cruise through the Choke. Media coverage of environmental watering in Barmah Forest raises the profile of the area drawing increased numbers of visitors from further afield bringing benefits to regional tourism industry and local businesses.
Local Community	The improved ecological condition of the forest from use of environmental water benefits physical, mental and social well-being of local residents. *NB: Exceptions are pro-horse groups who incorrectly accuse agencies of using e-water to force feral horses from Moira Grass wetlands to higher ground where less feed exists, and also from irrigation lobby groups who incorrectly blame any water diversion into the forest as 'overwatering' and killing Red Gum trees despite considerable evidence to the contrary.*
Traditional Owners	Drought refuge environmental watering targets turtles that are an important totemic species for the Yorta Yorta community. Floodplain Marsh watering improves the condition of vegetation that includes important food and medicinal plants for the Yorta Yorta community, such as Sneezeweed and Basket Sedge. Improved health of River Red Gums from environmental watering has benefits for important aboriginal sites such as alive significant trees and furthers connection to country. Broader restoration to health of Country.
Bird watching groups	Waterbird breeding environmental watering actions improve bird numbers and diversity in the forest to provide better birdwatching opportunities. Floodplain marsh environmental watering provides increased foraging grounds for birds and more birdwatching opportunities. Increase Red Gum health and flowering attracts and sustains more bushbirds.
Anglers	Drought refuge environmental watering maintains water quality in regulated creeks to support native fish and yabbies which provides enhanced angling opportunities. Environmental watering restores functions such as carbon and nutrient cycling by reconnecting the floodplain with the river channel. This has benefits for native fish downstream of Barmah Forest and leads to improved angling opportunities.
Apiarists	Improved health and flowering of mature trees from environmental watering provides benefits for apiarists within the forest. Increased use of the forest by apiarists has occurred following bushfires in other parts of the state in previous years reducing apiarist opportunities there.
Irrigators	Higher water levels in the Murray River lead to improved water access for some private diverters.

	Environmental releases improve water quality in the Murray River that benefits private diverters. Return flows of some e-water accounts are then available for irrigator diversion.
Other environmental water users	Diversion of flows through Barmah and Millewa Forest can assist each other with more elevated river levels than may occur had just irrigation water been released, as well as provides return credit flows (some allocations) that can bypass the constrictions of the Barmah Choke and hence be available for other downstream environmental water uses (such as the lower lakes and Coorong).

5.3 Current Ecological Conditions

As summarised in Table 6 above, and to be detailed in individual end-of-financial-year TLM monitoring reports and the annual Icon Site Report Card, the current ecological condition of Barmah-Millewa Forest is mixed, with excellent wetland and tree canopy response where flooding had influenced compared to sites that remained unflooded where vegetation exhibited some moisture stress despite above average rainfall conditions.

Four main natural flood peaks occurred between late-winter and spring (each consisting of two or more events that sustained the flood events well above-channel capacity), the largest peaking at 45,700ML/d in early September. E-water management bridged successive natural flood peaks to reduce the rate of flood recession from the floodplain that would otherwise have been caused by river regulation. River flow under modelled Natural Conditions indicate close to 100% of the B-M floodplain would have been inundated in August and September (not just the 55% that was experienced in September) and most of the lower half of the floodplain would have been continuously inundated between June and February.

As such, e-water management was crucial to at least maintaining some of the lower-level flooding on the floodplain to reflect more natural conditions than what would otherwise had occurred under current conditions without the e-water intervention. Numerous benefits to native wetland flora, fauna and ecosystem function occurred. These included the provision of suitable feeding habitat for the endangered Australasian Bittern (Figure 6) which is also likely to have successfully bred, and Little Bitterns were regularly heard calling from flooded wetlands containing reedbeds. Also of significance with the development of a substantial heronry that included approximately 1600 Rufous Night-heron (Figure 7), 25 Great Egret (Figure 8) and 75 Intermediate Egret (Figure 9) nests in Barmah Forest and likely to be a similar number in Millewa Forest. The white egret species nesting in Barmah Forest is of particular significance because this is likely to be the last remaining nesting site for these species in Victoria.

Results from fish, frog and turtle monitoring are still being collected and analysed, but early indications show that each of the taxa responded well to this year's flooding (pers. comm. with the respective researchers).

Figure 6: Australasian Bittern feeding on a yabby amongst the strong reedbed cover of Boals Deadwoods wetland sustained by e-water management (GB CMA trail camera photo, 26/12/2021)

Figure 7: Rufous night-heron nesting in Barmah National Park (Photo: Keith Ward, 06/12/2021)

Figure 8: Eastern Great Egret nesting in Barmah National Park (Photo: Keith Ward, 06/12/2021)

Figure 9: Intermediate Egret nesting in Barmah National Park (Photo: Keith Ward, 06/12/2021)

An average number of nesting cormorants was observed this year (spring 2021) with approximately 75 Little Pied Cormorant, 25 Little Black Cormorant and 1 Darter having successfully nested at Harbours Lake (Figure 10), while at Boals Deadwoods approximately 430 ibis nests (75% White Ibis and 25% Straw-necked Ibis) successfully fledged young (Figure 11).

Young of Musk Duck, Black Duck, Grey Teal, Purple Swamphen and Black Swan were found in many wetlands to indicate successful nesting from these species too.

Figure 10: Little Black and Little Pied cormorants nesting at Harbours Lake, Barmah Forest (Photo: Keith Ward, 22/12/2021).

Figure 11: Australian White Ibis chicks in nest at Boals Deadwoods wetland, Barmah National Park (Photo: Keith Ward, 21/02/2022).

Feral horse grazing exclusion fencing erected by GB CMA boosted the environmental gains achieved by the environmental watering on selected Floodplain Marshlands by protecting the vegetation from extreme grazing impacts (Figure 11). Kangaroos and insects still access the inside of the exclosure plots and where frequently observed feeding there.

Figure 12: Fence-line at Top Lake showing clear residual impact of grazing on LHS (09/11/2021).

5.4 Flow Components Delivered

The Barmah-Millewa Seasonal Watering Proposal 2021-22 (GB CMA 2021) had identified ten watering actions that were mostly hierarchical based on water resource scenarios and/or climatic triggers. Outcomes from the watering actions are outlined in Table 7 (hydrograph shown in Figure 3, above).

Table 7: Outcomes from the proposed watering actions at Barmah-Millewa Forest in 2021-22.

Watering action	Description of watering action	Outcome in 2021-22
Watering action A (Translucent Regulators)	Open forest regulators in July and close in late-November, irrespective of river level, to permit river fluctuations to gradually connect and disconnect with those waterways as would have occurred under more natural conditions.	Yes – Although regulators had to be fully opened for the passing of natural flood event in early-July and late-July (regulators were closed between), the regulators were then not closed after being re-opened for the passing of the late-July/early-August natural flood event until stage closure commenced mid-December.
Watering action B (Murray cod breeding)	Maintain flow within the main river channel at or above 8500 ML/day in late August through to December to support Murray cod nesting, survival and dispersal	Yes – Achieved through natural flooding, RMO air-space management and e-water delivery
Watering action C (Perch spawning pulses)	Provide flow variability within the main river channel in mid-October through to December to encourage the spawning of native fish species, primarily Silver Perch.	Yes – Achieved a "fish wriggle" flow (*which is creating some variation in river level, that looks like a wriggle on the hydrograph, to cause a rise/fall for promoting fish to spawn, given Golden Perch tend to spawn on the rising limb of the hydrograph and Silver Perch spawn on the recession*) by default given successive natural flood events during this period. Had these not occurred, then managed variability of e-water release was planned to occur. Monitoring found Golden Perch, Silver Perch and Murray Cod spawned.
Watering action D (Critical drought refuge)	Maintain critical drought refuge areas within Barmah-Millewa waterways, without return flow connectivity to the river system.	Yes – Achieved as part of Action E below.

Watering action	Description of watering action	Outcome in 2021-22
Watering action E (General drought refuge)	Maintain general drought refuge areas within Barmah-Millewa waterways, with return flow connectivity to the river system.	Yes – Achieved mostly through successive natural flood events between July to February, despite being augmented with some e-water release in winter-spring, to achieve adequate drought refuge with seven-month river connectivity.
Watering action F (Waterbird breeding – Dry scenario)	Sustain a waterbird (colonial-nesting species and bitterns) breeding event in Reed Beds Swamp or Moira Lake or Boals Deadwoods if a breeding event initiates following natural flooding and other required cues.	Yes – Achieved as part of Action G below.
Watering action G (Waterbird breeding – Moderate & Near Average scenarios)	As per Action F but with both Barmah AND Millewa wetlands.	Yes – Achieved with specific e-water diversion into Boals Deadwoods wetland between 06 January until 01 March 2022 after a nesting event initiated during the Floodplain Marshland e-water event (refer to Action I below). Approximately 430 Aust White Ibis and Straw-necked Ibis nested and fledged young (and suspect Aust bittern also bred), and slightly more in Reed Beds Swamp (Millewa Forest).
Watering action H (Waterbird breeding – Wet scenario)	Same as Action G but includes additional wetlands.	Yes – Achieved with low level flood maintenance as part of Action I (Floodplain Marchland flows) between natural flood events where approximately 100 cormorants (71% LPC and 19% LBC) and one Darter successfully nested..
Watering action I (Floodplain Marsh):	Build on natural flow cues to enhance conditions to promote growth of Floodplain Marsh vegetation species (including Moira Grass) on treeless plains in Millewa Forest (given that it is Millewa Forest's turn under annual-alternating flood strategy with Barmah Forest).	Yes – Achieved in both Barmah and Millewa forests primarily because of successive large natural flood events with some River Operations air-space management releases from Hume Reservoir. E-water releases successfully bridged the higher flows when these were otherwise to fall below 15,000ML/d, but all Barmah and Millewa forest regulators were left open given the frequency of natural flood events to achieve suitable flooding on the Floodplain Marshlands in both Barmah and Millewa forests. This resulted in excellent growth and flowering of Moira Grass, and combined with the grazing-exclusion fences in Barmah Forest, also resulted in strong protection of the nationally-endangered River Swamp Wallaby Grass (*Amphibromus fluitans*).
Watering action J (Autumn-winter perennial flows)	Maintain river releases from Yarrawonga above 4,000 ML/d in autumn-winter for large-bodied native in perennially flowing habitats but exit (or attempt to exit) the seasonal habitat when flows cease.	Scheduled for Autumn 2022 (noting that this strategy was employed last Autumn where it was achieved.

5.5 Key Observations and Learnings

The key observations and findings from the planning, delivery and monitoring of environmental water in 2021/22 include:

- Air space management of Hume Reservoir during spring provided benefit to the flooding of Barmah-Millewa Forest without cost to e-water accounts.
- Natural floods (peaking ~45,000 ML/d) provided for broader floodplain inundation than that achieved using e-water deliveries alone (max. 15,000ML/d) due to constraints on managed flows limiting the volumes that could be delivered each day.
- Had natural conditions still been operation, two very large floods (~80,000 ML/d) would have occurred to have inundated close to 100% of the Barmah-Millewa floodplain. However, river regulation mitigated the peak flows to instead inundate approximately 55% of the floodplain.
- Reasonable number of colonial waterbirds successfully nested this year, although concern continues to exist for the overall general decline in ibis numbers (~430 nests in Barmah and ~600 in Millewa) which form part of the Ramsar ecological character of the sites.
- Significant numbers of Rufous Night-heron nested this year (~1600 nests in Barmah and possibly a similar number in Millewa).

- Two of the three white egret species nesting amongst the night-herons, although numbers were low at ~100 in Barmah (75% intermediate Egret and 25% Great Egret) and possibly similar in Millewa. Nevertheless, the nesting attempt represents the last known nesting of the species in Victoria.
- Approximately 100 cormorant nests occurred in Barmah Forest (20% Little Pied and 25% Little Black), and one Darter nest, which is around average over the recent decade.
- Only small numbers of waterfowl (primarily Grey Teal, Black Duck, Musk Duck and some Black Swan) were observed breeding. Australasian Bittern and Little Bittern were also heard calling within most reed-dominated wetlands throughout the forest and suspected to have successfully nested.
- Moira Grass (*Pseudoraphis spinescens*) appears to be re-colonising floodplain areas where protected from large herbivores where the flood regime was appropriate. However, no substantial improvement in re-colonisation has yet occurred to counter recent decades of loss despite seemingly suitable flood regimes having occurred.
- Translucent Regulator operations in August and September (water losses to the forest were underpinned by environmental water accounts) progressively diverted some water through both Barmah and Millewa forests until environmental water releases commenced in mid-October for broader forest inundation and to bridge natural flood peaks.
- The bulk of environmental water releases were made in mid-October (at maximum permissible constraint of 15,000ML/d from Yarrawonga) to target Floodplain Marshlands (Moira Grass plains) until mid-November when larger natural floods occurred until tapering back to regulated river channel capacity of 9,000ML/d in mid-December.
- The slow recession was to minimise the risk of fish and turtle strandings on the broader floodplain.
- Flows were generally equally shared between Barmah and Millewa forests, with slight bias to maintaining all Millewa Forest regulators fully open, especially when targeting a fish exit strategy towards the end of main flood event.
- Unseasonal flooding occurred in mid-January and early-February caused by high rainfall totals in the upper catchment. This warranted all Barmah and Millewa forest regulators to be re-opened. The impact of this on the wetlands is likely to have been less than had the wetlands had a chance to significantly dry following the broader spring forest flood event. However, hypoxic blackwater did develop.
- Hypoxic blackwater development in January and February fortunately did not result in any known fish deaths incidents. It is likely that higher dissolved oxygen concentrations in the Murray River provided adequate refuge for any fish that could have escaped from the lower forest waterways back into Barmah Lake and the adjoining river.

6 Scenario Planning

Note: This section is not required to be filled in for Murray River Icon Sites given that the detail has been provided in the SCBEWC water proposal template (provided in Appendix A of this report).

7 Delivery Constraints

There are two known delivery constraints that could influence the delivery of environmental water to the Barmah-Millewa Icon Site (Table 8). Firstly, the imposed flow constraint on the Murray River downstream of Yarrawonga currently limits releases to a maximum of 18,000 ML/d until the end of September (pending Bullatale Creek landholders' approval) and to 15,000 ML/d for the remainder of the year to prevent flooding of private access points across the Bullatale Creek system in NSW. In recognition of this constraint, this 2022-23 watering proposal accepts that both Barmah and Millewa

Forest cannot achieve Floodplain Marsh flood inundation to the required minimum depths if both forests were to be flooded during the same managed e-water event, and hence instead accepts a continuation of the local "seasonal annual alternating management" agreement with Millewa Forest whereby only one of the forests can be flooded at the minimum depth target in any given event. Given that Millewa Forest was scheduled to be preferentially flooded in 2022-23, then this coming year will therefore be Barmah Forest's turn to attempt Floodplain Marshland flood depth and duration and thus work within the current maximum water delivery constraints.

Table 8: Delivery constraints

Priority environmental site	Potential constraint	Impact on priority watering action
Barmah-Millewa Forest	Bullatale Creek flooding of access to private land issue unresolved	Limited to releases of 18,000 ML/d until the end of September (pending Bullatale Creek landholders' approval) and 15,000 ML/d thereafter.
Barmah Forest	MDBA River Operations need to supply bulk water delivery through Barmah Forest during August to December 2022, thereby using full Murray River channel capacity and thus rendering inability to deliver environmental water to Millewa Forest given prefer to pass water through Barmah Forest.	Cannot deliver to Millewa Floodplain Marsh plains if this situation arises, hence will capitalise on Barmah Forest flooding to ensure developing environmental gains are achieved (e.g., maintain flows to complete waterbird nesting outcomes if one initiates during River Ops delivery).

8 Increasing Knowledge

8.1 Monitoring

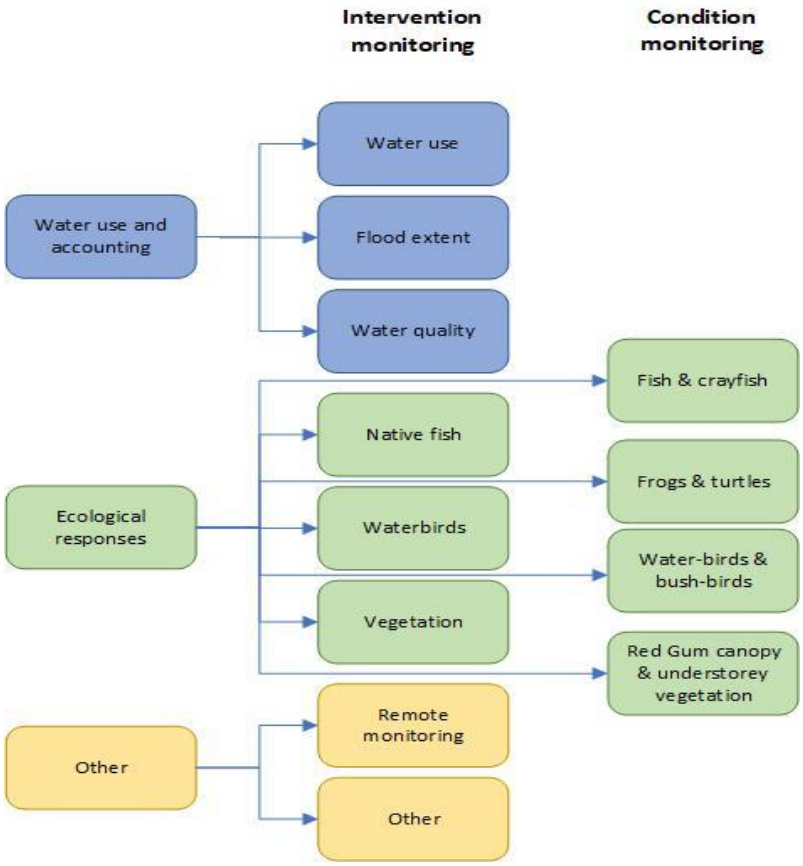
A broad range of monitoring occurs at Barmah-Millewa Forest that provides information to inform the condition (health), adaptive water management and environmental outcomes at the site. Each year since 2006 (curtailed in some years), The Living Murray (TLM) Initiative provides budget for both Condition Monitoring and Intervention Monitoring at the Barmah-Millewa Icon Site. Although these budgets have not yet been confirmed for the 2022-23 year, there is an expectation that similar levels of budget will be provided as has been in previous years.

Condition Monitoring is undertaken using repeat standard measures and sites over the long-term. The primary focus of Condition Monitoring is to determine whether the objectives for the Barmah-Millewa Icon Site, identified in the Environmental Water Management Plan (MDBA 2012), are being met. The scope of Condition Monitoring is focused on fish, birds and vegetation communities as defined in the TLM Outcomes Evaluation Framework. This has extended to include frog and turtle condition monitoring since 2018-19.

Condition Monitoring projects which are planned to continue in 2022-23 are:

- Waterbirds
- Bush birds
- Understory vegetation
- Stand condition
- Fish and crayfish
- Frogs and turtles

Intervention Monitoring is the collective name given to compliance, risk and adaptive management monitoring and is undertaken to measure a response to a management activity. Intervention Monitoring activities may differ year-to-year. A full Intervention Monitoring proposal for the Barmah-Millewa Icon site for 2022-23 is currently in preparation and will be provided to TLM by 9th May. The general structure of the 2022-23 intervention monitoring plan is shown below. Individual projects will fit into the following categories or sub-categories:



It is anticipated that some funding from the Intervention Monitoring budget will go towards projects that are multi-year projects. These include:

- Agency surveillance of wetlands and waterbirds
- Water quality monitoring using telemetered dissolved oxygen probes
- Leaf litter assessment for blackwater modelling
- Fish passage through regulators
- Fish movements within forest waterways
- Turtle tracking

There are several other non-TLM funded research or monitoring projects that will take place in Barmah-Millewa Forest in 2022-23.

The Arthur Rylah Institute (ARI) are undertaking a Victorian Wetland Monitoring and Assessment Program for environmental water (WetMAP) project that recently extended to Barmah Forest to

survey the response of small-bodied fish on the floodplain. This project will continue in Barmah Forest through 2022-23. There is also potential for some university monitoring projects to occur (pending funding)

8.2 Reporting

Outcomes of environmental water activities will be variously reported, with DELWP/Parks Victoria approval, as has occurred in past years.

This includes use of the following:

- social media during the watering event as outcomes of interest occur (such as via the various agencies Facebook and Twitter accounts);
- media releases relating to specific advice or issue (with potential for print, radio and TV exposure);
- weekly reports to VEWH via existing template;
- monthly reports to GB CMA Board;
- minutes associated with the Barmah-Millewa Operations Advisory Group teleconferences (usually held weekly during active water management events);
- occasional opportunistic articles of interest to special interest magazines (such as Birdlife Australia);
- involvement in other project steering committees or workshops;
- provision of seminars to special interest groups (such as Australian Society for Limnology, local community groups and agency staff);
- potentially inclusion into scientific literature where appropriate (such as reporting outcomes from a particular study or monitoring program associated with environmental water).
- Encouraging researcher involvement into an issue of environmental water management interest, and thereby potentially create broader exposure to other groups.

8.3 Knowledge Gaps and Limitations

Existing knowledge gaps will be targeted, where possible, for investigation through existing and/or planned research and monitoring projects, or where opportunistic investigations may assist answering. Usefulness of observational history (as a form of multiple lines of evidence or to develop hypothesis for future testing) is also recognised as being important. The following is a brief range of projects that could assist with future water management outcomes:

- Bird movements – particularly for colonial nesting species. This includes migration (when and where) and what cues stimulate nesting in Barmah-Millewa Forest and broader regions where birds have been captured and tagged. The waterbird tracking project commenced as an EWKR-funded project between 2015-19 and has since continued as a CEWO-funded project. The project has already greatly assisted with answering many basic movement questions whilst continuing to discover much more and providing useful considerations for water management. Further opportunity remains to capture additional birds for tagging at the BMF Icon Site.
- Large-bodied fish movements, spawning & recruitment – cues responsible for accessing the main river, creeks and wetlands, breeding, larvae drift, recruitment migration and movement response to water quality, as well as cues responsible for inducing spawning and recruitment outcomes. This is being investigated through Barmah-Millewa Intervention Monitoring in addition to other research projects along the Murray River.

- Small-bodied wetland dependant fish – identify sites within BMF where flows and physical habitats could be maintained/restored to help restore populations of small-bodied fish species such as the Southern Pygmy Perch. ARI is currently investigating potential re-introduction sites in Barmah Forest for SPP and possibly also Purple-spotted Gudgeon.
- Frogs – species, numbers, breeding locations and cues, and recruitment outcomes. Currently being investigated by Barmah-Millewa Condition Monitoring project.
- Murray Crayfish – population, movement and the impacts of blackwater events. Currently being investigated by Barmah-Millewa Condition Monitoring project.
- Turtle movements – continue GPS transmitter tracking of a sample of turtles of all three species to determine movements in relation to water management and nesting locations (which also has ramifications for pest animal control programs and potential drought refuge management).
- Macro invertebrates – very little is known of their significance or water requirements in Barmah-Millewa Forest.
- Causes and significance of filamentous algae coating wetland plants at Barmah-Millewa wetlands in occasional years.
- Carbon cycling – importance of floodplain-riverine interaction to support riverine food-webs (thereby potentially increasing the importance of return flow management).
- Rare or threatened species – undertake targeted surveys to determine location for potential water management.
- Erosion and sedimentation rates (main river channel and other waterways) – value would be obtained from re-surveying existing erosion monitoring transect sites in Barmah Forest that have previously survey data from 1998, 1999, 2002 and 2006, in addition to MDBA's sand slug and erosion studies.
- Exploring best method (particularly timing) to restore wetlands with Moira Grass propagules. Currently subject to a Ramsar-funded project managed by GB CMA.
- Further refine ability to remotely map distribution of Moira Grass (and other targeted species). Recent Ramsar-funded project managed by GB CMA showed some encouraging results, but this needs to be refined.
- Encourage greater indigenous water aspirations for inclusion into future water management strategies and activities.

9 Risk Management

The main operational risks associated with environmental watering are outlined in Table 9, as derived following consideration via a workshop convened by VEWH via *MS Teams* on 22 February 2022. More specific information relating to risks at the Barmah-Millewa Icon Site are outlined in the SCBEWC water proposal (provided in Appendix A of this report).

Table 9: Risk assessment of proposed water delivery

VEWH risk assessment: Risk assessment for 2022-23 watering proposals – risks applying to Murray and Barmah sections only-

Blue text indicates common risks across systems
Black text indicates system specific risk
Purple text indicates changes added in 2021 risk workshops
Red text indicates changes added in 2022 risk workshop

							Pre-Mitigation Risk						Residual Risk				
FY	Region	System	Waterway Manager	Risk ID	Risk category	Risk description	Likelihood	Consequence	Risk Rating	Mitigation actions	Lead organisn. for action	Likelihood	Consequence	Risk Rating	Remains medium/high after mitigation	Risk type Static or Dynamic
2019-20	Northern	Murray, Goulburn, Broken & Ovens	GBCMA & NECMA	NOGB2020-01	Environment	Specified flow rates are insufficient to achieve the intended extent of wetland inundation or magnitude and duration of river flows, resulting in a failure to achieve planned environmental outcomes.	Possible	Major	Medium	• Include contingency allowance in estimated watering requirements, based on previous event data, and consider a contingency in the duration of the event to achieve desired wetland inundation. • Monitor event (especially for deliveries to new sites or for previously untested events) and adjust flows as necessary, or terminate event if it becomes clear that insufficient water is available. • Identify and address constraints that may limit the flow rates for environmental deliveries.	CMA CMA CMA/GMW	Possible	Major	Medium	Medium	Static
2019-20	Northern	Murray, Goulburn, Broken & Ovens	GBCMA & NECMA	NOGB2020-02	Reputational	Specified flow rates are insufficient to achieve the intended extent of wetland inundation or magnitude and duration of river flows, resulting in a failure to achieve planned environmental outcomes and loss of community support.	Possible	Major	Medium	• Communications on the environmental benefits of watering actions. • Monitor event (especially for deliveries to new sites or for previously untested events) and adjust flows as necessary, or terminate event if it becomes clear that insufficient water is available. • Communicate the need for complimentary measures to optimise the benefits of environmental watering actions.	CMA	Possible	Major	Medium	Medium	Static
2019-20	Northern	Murray, Goulburn, Broken & Ovens	GBCMA & NECMA	NOGB2020-03	Environment	Overestimates of environmental water demand prevents planning for supplying demands at other locations *Notes: Planning watering actions also includes decisions around the carryover and trade of water as alternatives to current year water use decisions.*	Possible	Minor	Low	• CMAs review demand estimates and targets met by unregulated flows throughout the delivery cycle and regularly advise VEWH of any changes so unused water can be reallocated. • CMAs review demand estimates at the conclusion of the watering year, prior to the development of the following seasonal watering proposal, so estimates of future requirements are more accurate. • River operators provide regular updates on flows, including through OAG meetings • Manage Water Holdings to maximise supply opportunities for all sites	CMA CMA MDBA/GMW VEWH	Possible	Minor	Low		Static
2019-20	Northern	Murray, Goulburn, Broken & Ovens	GBCMA & NECMA	NOGB2020-04	Environment	Inaccurate accounting and measurement or operational error results in target flows either not being achieved or being exceeded, leading to a failure to achieve planned environmental outcomes Occurring in Upper Broken CK below Casey's weir offtake due to weed growth, which is also limiting flow capacity (likelihood for Broken is "possible")	Unlikely	Moderate	Low	• Review accounting and measurement processes to be used to ensure that techniques are agreed, and monitoring/measurement sites are operational. - Apply agreed arrangements as documented in the Murray and Goulburn Systems Operating Arrangement documents - GMW to undertake additional gaugings - Weed control in Bkn Ck programmed for autumn (weather conditions permitting)	GMW (MDBA in some waterways such as Barmah) GMW/VEWH GMW GMW/CMA	Unlikely	Moderate	Low		Dynamic
2019-20	Northern	Murray, Goulburn, Broken & Ovens	GBCMA & NECMA	NOGB2020-05	Business Costs	Volumes of environmental water delivered or released exceed volumes approved for use in the event, leading to potential overdrawing of accounts or preventing other planned actions being undertaken. *Notes: Planning watering actions also includes decisions around the carryover and trade of water as alternatives to current year water use decisions.*	Unlikely	Major	Low	• Ensure that deliveries are reported progressively throughout the event and are monitored against ordered volume. • Ensure ordering and delivery procedures are kept up-to-date and adhered to. • Ensure metering and reporting processes for temporary pump operations are suitable and effective	CMA & GMW GMW/CMA/VEWH CMA	Unlikely	Major	Low		Static
2019-20	Northern	Murray, Goulburn, Broken & Ovens	GBCMA & NECMA	NOGB2020-06	Environment	Environmental water account is overdrawn, leading to water not being available as per approved watering statement to complete planned actions and environmental benefits not being achieved. *Notes: Planning watering actions also includes decisions around the carryover and trade of water as alternatives to current year water use decisions.*	Unlikely	Major	Low	• Monitor ABA balances and undertake regular communications with CMA and RWC as part of portfolio management activities. • Ensure that deliveries are reported progressively throughout the event and are monitored against ordered volume.	VEWH CMA & GMW	Unlikely	Major	Low		Static

							Pre-Mitigation Risk						Residual Risk				
FY	Region	System	Waterway Manager	Risk ID	Risk category	Risk description	Likelihood	Consequence	Risk Rating	Mitigation actions	Lead organisn. for action	Likelihood	Consequence	Risk Rating	Remains medium/high after mitigation	Risk type Static or Dynamic
2019-20	Northern	Murray, Goulburn, Broken & Ovens	GBCMA & NECMA	NOGB2020-07	Environment	Planned maintenance of water delivery infrastructure results in planned/specified flows not being achieved, leading to a failure to achieve planned environmental outcomes.	Likely	Minor	Low	• Undertake early planning and communications between the CMA and storage operator to minimise likelihood of constraints, enable scheduling of maintenance outside of high demand periods or identify alternative environmental water delivery windows to avoid scheduled maintenance activities. • Consider adding time contingencies to planned maintenance schedules to ensure works are completed prior to commencement of watering actions.	CMA and GMW CMA	Possible	Minor	Low		Static
2019-20	Northern	Murray, Goulburn, Broken & Ovens	GBCMA & NECMA	NOGB2020-08	Environment	Failure of poorly maintained environmental delivery infrastructure results in planned/specified flows not being achieved, reducing the ability to achieve planned environmental outcomes.	Likely	Moderate	Medium	• Asset ownership is clarified, and the asset owners perform regular maintenance, and pre-event asset inspections, on delivery infrastructure. *Note that insufficient resources are likely to limit the asset owner's ability to regularly inspect and maintain infrastructure. Increased resources for these activities may further reduce the likelihood and risk ratings.* • Report vandalism to police. • Review asset design to minimise opportunities for interference or damage. • For privately owned assets, arrange approvals to use/operate assets and undertake pre-delivery inspections • Communicate failures to the CMA • Initiate documentation of asset ownership and management arrangements in national parks.	Asset Owner Asset Owner Asset Owner CMA Asset Owner PV	Likely	Moderate	Medium	Medium	Static
2019-20	Northern	Murray, Goulburn, Broken & Ovens	GBCMA & NECMA	NOGB2020-09	Environment	Poor condition of delivery infrastructure results in the asset owner being unable to operate the structure due to OH&S risks, leading to failure to deliver environmental flows and to achieve environmental objectives. Note: This issue may affect multiple sites *GMW to confirm OH&S status and likelihood rating*	Likely	Moderate	Medium	• Asset owner to undertake regular maintenance and pre-event asset inspections on delivery infrastructure. *Note that insufficient resources are likely to limit the asset owner's ability to regularly inspect and maintain infrastructure. Increased resources for these activities may further reduce the likelihood and risk ratings.* • Communicate failures to the CMA • Develop design for new regulating structure and seek funding to implement necessary upgrades in conjunction with asset owner. *Note: PV proposing to issue operating licences for BMF regulators*	Asset Owner Asset Owner CMA (MDBA in Barmah Forest)	Likely	Moderate	Medium	Medium	Dynamic
2019-20	Northern	Murray, Goulburn, Broken & Ovens	GBCMA & NECMA	NOGB2020-10	Environment	High operational and consumptive water demands lead to reduced access for environmental deliveries, with the result that target flows/volumes cannot be achieved, impacting on environmental outcomes Note: Goulburn R is a particular risk - see new separate Goulburn risk added	Likely	Minor	Low	• Event planning will seek to avoid peak demand periods, and events will be monitored and adjusted as necessary. • System operators to provide longer term forecasts for future consumptive demands as an input to planning watering proposals • Develop longer term agreements on river capacity access for environmental deliveries. • Investigate opportunities to undertake deliveries outside the irrigation season with consideration of appropriate delivery costs	CMA and GMW GMW/MDBA VEWH CMA and VEWH	Unlikely	Moderate	Low		Dynamic
2019-20	Northern	Murray, Goulburn, Broken & Ovens	GBCMA & NECMA	NOGB2020-11	Environment	High downstream demands may lead to flows that exceed local environmental requirements and targets (including rates of river rise and fall), leading to negative environmental outcomes, including negating previous environmental improvements. Recent monitoring and assessment is confirming consequences in Goulb and Lwr Bkn - high water avail. in 22-23 increases likelihood	Almost certain	Major	Extreme	- Seek to negotiate and formalise acceptable seasonal flow limits for river systems, with annual negotiation and management of release plans and reviews during the season as required. - Monitor impacts of new trade limits and revised operating rules and review as necessary (Note: This risk may still be rated as *extreme* after mitigation actions.)	VEWH and DELWP DELWP/GBCMA	Possible	Moderate	Medium	Medium	Dynamic
2019-20	Northern	Murray, Goulburn, Broken & Ovens	GBCMA & NECMA	NOGB2020-12	Legal	Environmental releases, either on their own or potentially in combination with unexpected tributary inflows, cause unauthorised inundation of private land, resulting in impacts on landowner activities and assets.	Possible	Major	Medium	• Ensure currency of any landholder agreements for inundation of private land. • Release plans designed to avoid exceeding operational thresholds or unauthorised flooding. • Monitor events and adjust releases to avoid overbank flows. This may include limiting deliveries to daylight hours only, where feasible and consistent with watering requirements. • Monitor forecast rainfall and tributary inflows and adjust releases to avoid overbank flows. • Monitor deliveries to new locations to build an understanding of flow patterns and inundation thresholds and adjust releases accordingly.	CMA CMA GMW/MDBA GMW/MDBA CMA	Unlikely	Moderate	Low		Static
2019-20	Northern	Murray, Goulburn, Broken & Ovens	GBCMA & NECMA	NOGB2020-13	Reputational	Public land and/or access routes into public land areas may be inundated by delivery of environmental water, leading to potential impacts on recreational opportunities for park users (e.g. access to boat ramps, fishing spots, firewood collection etc.).	Almost certain	Moderate	High	• Watering proposals to identify potential impacts. communication of planned events, access closures, alternative recreational opportunities and alternative access routes	CMA Land Manager	Almost certain	Minor	Medium	Medium	Static
2019-20	Northern	Murray, Goulburn, Broken & Ovens	GBCMA & NECMA	NOGB2020-14	Reputational	Environmental water delivery results in inundation of roads and recreation areas (e.g. Barmah Forest campsites) during their use, potentially stranding recreational users.	Possible	Moderate	Medium	• Watering proposals to identify potential impacts (e.g. flooding footprint overlaid with key land roads and recreational assets). • Land Managers implement the required management activities prior to and during environmental watering events. This includes: ▪Identification of impacted assets ▪Preparation of resources required (e.g. signage, maintenance of alternative recreational sites) to implement road and campsite closures and to direct users to alternative sites ▪Communication of planned events, access closures and alternative recreational opportunities. ▪Land managers to seek powers to temporarily close roads without the need for a gazettal process. ▪Land managers given powers to remove people from affected areas and establish day visitor areas. ▪Consider rationalisation of road networks to remove unwanted access tracks and improve the standard of retained tracks. **Note that insufficient resources may limit the land manager's ability to implement management activities and hence ability to effectively mitigate the described risk.*	CMA Land Manager	Possible	Moderate	Medium	Medium	Static
2019-20	Northern	Murray, Goulburn, Broken & Ovens	GBCMA & NECMA	NOGB2020-15	Business Costs	Public land visitor vehicles cause damage to tracks, or to other assets in the surrounding landscape, due to off-road activity (by users going off track to avoid floodwaters) during and after environmental watering	Likely	Moderate	Medium	Land Managers: ▪Implement management activities to prevent access to flooded roadways (e.g. close roads, communicate planned events, install signage) ▪Repair damage during and after environmental watering events ▪Maintain key higher ground tracks to enable alternative access routes during environmental watering. **Note that insufficient resources may limit the land manager's ability to implement management activities and hence ability to effectively mitigate the described risk.*	Land Manager	Almost certain	Minor	Medium	Medium	Static
2019-20	Northern	Murray, Goulburn, Broken & Ovens	GBCMA & NECMA	NOGB2020-16	Legal	Access routes into public land areas may be inundated by delivery of environmental water, leading to potential economic impacts on commercial operators who are unable to undertake activities (includes timber and firewood harvesting, apiarist, tourism operators).	Likely	Moderate	Medium	Communication and advice to commercial operators to alert them of environmental watering, via Land Manager as licensing authority.	Land Manager	Unlikely	Minor	Low		Static
2019-20	Northern	Murray, Goulburn, Broken & Ovens	GBCMA & NECMA	NOGB2020-17	Service Delivery	Access routes into public land areas may be inundated by delivery of environmental water, leading to potential impacts on land management and maintenance activities (e.g. fire mgmt. works)	Almost certain	Moderate	High	Early planning and communications of proposed actions with land manager to minimise likelihood of impacts, and scheduling of maintenance works outside of planned delivery periods.	CMA	Almost certain	Minor	Medium	Medium	Static
2019-20	Northern	Murray, Goulburn, Broken & Ovens	GBCMA & NECMA	NOGB2020-18	Environment	Environmental water deliveries result in low dissolved oxygen (DO) levels, with adverse environmental impacts. *Note: Advice is that annual leaf litter accumulation is sufficient to cause risk, even if previously inundated* *- Rainfall rejection or high consumptive deliveries may drive risk issues here, rather than e-water*	Unlikely	Moderate	Low	• Where possible implement a full annual suite of flow components in river systems, including those designed to control build of organic matter (such as winter flushes). Plan deliveries with consideration of high temperature periods where appropriate. • Develop monitoring and response plans and reserve contingency volumes in delivery plans for dilution flows if DO concentrations drop to levels of concern. • Monitor leaf litter loads and avoid exceeding any flow thresholds likely create hypoxic black water events - where possible, and considering temperature drivers - Assess new/proposed actions for DO impact potential and adjust watering plans as needed.	CMA	Unlikely	Moderate	Low		Dynamic

							Pre-Mitigation Risk						Residual Risk			
FY	Region	System	Waterway Manager	Risk ID	Risk category	Risk description	Likelihood	Consequence	Risk Rating	Mitigation actions	Lead organisn. for action	Likelihood	Consequence	Risk Rating	Remains medium/high after mitigation
2019-20	Northern	Murray, Goulburn, Broken & Ovens	GBCMA & NECMA	NOGB2020-19	Reputational	Environmental water deliveries result in low DO levels, with adverse environmental impacts.	Unlikely	Major	Low	• Communicate benefits of environmental water management to the broader community and engage with recreational user peak bodies and management agencies. • Communicate the benefits of environmental water management and inform the local community of environmental water management activities and the underlying rationale, including black water mitigations. - Inform communities of black water vs hypoxic black water issues, to build understanding and support	VEWH CMA - VEWH/CEWO	Unlikely	Moderate	Low	
2019-20	Northern	Murray, Goulburn, Broken & Ovens	GBCMA & NECMA	NOGB2020-20	Environment	Environmental water deliveries may generate or mobilise BGA blooms, with adverse water quality and/or health impacts (including to people, livestock and pets), resulting in cessation of releases and environmental impacts	Possible	Major	Medium	• Consider likelihood of initiating BGA blooms in event planning and amend as required to manage risk. • Land managers or water corporation implement a risk-based monitoring program during environmental watering events, and where issues are identified, activate BGA response processes. *Notes: Parks Victoria are currently writing a BGA risk management plan for Northern Victoria Region that considers the potential risk of environmental water events. This plan will outline proactive and reactive monitoring and management responsibilities that Parks Victoria commits to as a Local Waterway Manager for BGA. Adequate BGA resourcing is being considering as part of this plan.* • Regional monitoring and advice on BGA status.	CMA / GMW Land Manager GMW GMW	Unlikely	Moderate	Low	
2019-20	Northern	Murray, Goulburn, Broken & Ovens	GBCMA & NECMA	NOGB2020-21	Reputational	Environmental water management activities may conflict with or not complement water based recreational objectives, leading to loss of community support for activities.	Almost certain	Moderate	High	• Communicate benefits of environmental water management to the broader community and engage with recreational user peak bodies. • Engage with local recreational user groups to inform them of environmental water management activities and the underlying rationale. • Adjust events or actions to reduce/avoid impact where practical without reducing environmental outcomes. • Communicate alternate recreational opportunities. • Enhance community understanding of water system operations and entitlement frameworks (water literacy).	VEWH CMA CMA Land Manager VEWH	Likely	Minor	Low	
2019-20	Northern	Murray, Goulburn, Broken & Ovens	GBCMA & NECMA	NOGB2020-22	Business Costs	Insufficient resources available (including staff, funding for maintenance of roads, regulators etc.) across partner organisations to deliver all planned environmental watering actions, leading to cancellation or interruptions of deliveries.	Possible	Major	Medium	• Partners notify the CMA and VEWH of resource constraints in advance of deliveries and VEWH convene OAG meetings to consider implications and potential solutions. • Continue to actively prioritise actions to match available resources and ensure key actions are delivered. • Reallocate tasks and available funds to ensure highest priority watering actions are delivered.	VEWH CMA CMA	Unlikely	Minor	Low	
2019-20	Northern	Murray, Goulburn, Broken & Ovens	GBCMA & NECMA	NOGB2020-23	Environment	Insufficient information and knowledge available to inform environmental water deliveries	Unlikely	Moderate	Low	• Identify important knowledge gaps and secure funding to improve scientific understanding. • Consider deferring deliveries until sufficient information is available to mitigate unacceptable risks. • Implement adaptive management processes and undertake trials to collect data.	CMA	Unlikely	Minor	Low	
2019-20	Northern	Murray, Goulburn, Broken & Ovens	GBCMA & NECMA	NOGB2020-24	Legal	Failure to recognise cultural heritage issues at a site targeted for watering may result in necessary permits and approvals not being obtained, leading to prosecution and fines.	Possible	Moderate	Medium	• Undertake desktop reviews and site assessments with archaeologists, traditional owners and land managers, to identify approval needs and contingency measures. • Obtain any necessary formal approvals/permits and implement required actions.	CMA	Unlikely	Moderate	Low	
2019-20	Northern	Murray, Goulburn, Broken & Ovens	GBCMA & NECMA	NOGB2020-25	Cultural heritage	Environmental watering causes harm to identified cultural heritage *Note: difficult to assess consequence under cultural heritage category - needs further testing with TOs. Hard for non-TOs to try and assess, so doesn't really fit within a traditional risk assessment process*	Unlikely	Moderate	Low	• Work with Traditional Owners to ensure that the potential impact of environmental water deliveries on cultural heritage is understood and agreed, minimised or avoided. - Consider opportunities for additional resourcing for TO groups to engage in risk assessments	CMA DELWP/VEWH	Unlikely	Moderate	Low	
2019-20	Northern	Murray, Goulburn, Broken & Ovens	GBCMA & NECMA	NOGB2020-26	Reputational	Inability to demonstrate outcomes achieved through environmental watering activities may lead to a loss of public/political support for activities	Possible	Major	Medium	• Rationalise and refocus current monitoring programs (e.g. Wetmap) to better identifying outcomes. • Seek additional funds to address gaps in monitoring programs and knowledge. • Communicate the benefits of environmental watering and monitoring results (Note: It may not be possible/affordable to address all monitoring gaps, so this risk may still be rated as medium after mitigation actions.)	DELWP VEWH CMA	Possible	Moderate	Medium	Medium
2019-20	Northern	Murray, Goulburn, Broken & Ovens	GBCMA & NECMA	NOGB2020-27	Environment	Environmental deliveries improve conditions for non-native species (e.g. carp, invasive species, feral horses) and over-abundant native species (e.g. kangaroos, Red Gum encroachment) leading to adverse environmental impacts.	Likely	Moderate	Medium	• Study/understand life history of species and develop high level management strategies. • Develop and implement site specific management strategies aimed at eradication/control of existing populations (e.g. carp management strategy, willow removal program, water-lily spraying program, feral animal programs). - Implement pest reduction efforts prior to delivery of water, to ensure increases in populations remain within "tolerable" levels *(Note: This risk is still rated as medium after mitigation actions.)*	DELWP CMA/Land Manager	Possible	Moderate	Medium	Medium
2019-20	Northern	Murray, Goulburn, Broken & Ovens	GBCMA & NECMA	NOGB2020-28	Environment	Environmental watering actions trigger non-targeted environmental responses (e.g. bird breeding) causing unintended consequences (or lost opportunities) for other environmental values.	Likely	Moderate	Medium	• Undertake monitoring and communicate these issues as they arise and apply adaptive management and review of delivery plans. • Consider including contingency allowance in delivery plan water volumes to complete breeding events.	CMA	Possible	Moderate	Medium	Medium
2019-20	Northern	Murray, Goulburn, Broken & Ovens	GBCMA & NECMA	NOGB2020-29	Environment	Ineffective planning and/or uncoordinated water ordering results in administrative obstacles that prevent watering opportunities.	Unlikely	Moderate	Low	• Enable the full range of watering actions possible in seasonal watering proposals and the seasonal watering plan (as per SWP guidelines) - Review and update the Murray system environmental watering ordering template	CMA/VEWH VEWH/MDBA	Unlikely	Moderate	Low	
2019-20	Northern	Murray, Goulburn, Broken & Ovens	GBCMA & NECMA	NOGB2020-30	Business Costs	River operators release water for flood mitigation which causes downstream flooding and debits those releases to environmental water accounts *Note that debits of releases to environmental accounts is specific to Lake Hume and pre-releases from other storages could not be debited to environmental accounts*	Unlikely	Moderate	Low	• Resolve appropriate water accounting treatment as part of the development of the Enhanced Environmental Water Deliveries SDL Adjustment Measures project (aka Hydrocues project) • Refer to MDBA Environmental Water Management Group for development of suitable accounting arrangements.	VEWH/DELWP MDBA	Unlikely	Moderate	Low	
2019-20	Northern	Murray, Goulburn, Broken & Ovens	GBCMA & NECMA	NOGB2020-31	Reputational	River operators release water for flood mitigation which causes downstream flooding and public perceive the releases are for environmental purposes.	Unlikely	Moderate	Low	• River operators to clearly communicate to customers and the broader community when large releases are for operational purposes	MDBA/GWM	Unlikely	Minor	Low	
2019-20	Northern	Murray, Goulburn, Broken & Ovens	GBCMA & NECMA	NOGB2020-32	Reputational	Sections of the community perceives (incorrectly) that high river flows are due to environmental releases in dry conditions, leading to a loss of support for watering activities.	Possible	Moderate	Medium	• Communications to inform the community on the drivers/reasons for high flows in river systems, especially under dry scenarios	System operator & CMA	Possible	Minor	Low	
2019-20	Northern	Murray, Goulburn, Broken & Ovens	GBCMA & NECMA	NOGB2020-33	Reputational	Community concern over environmental releases under dry seasonal conditions may lead to a loss of support for environmental watering actions.	Likely	Moderate	Medium	• Communicate benefits of environmental watering to the community, especially in relation to strategic watering in dry periods. • Enhance community understanding of water system operations and entitlement frameworks (water literacy).	CMA VEWH	Possible	Minor	Low	
2019-20	Northern	Murray, Goulburn, Broken & Ovens	GBCMA & NECMA	NOGB2020-34	Reputational	Under dry conditions, community expectations of the extent of environmental watering that can be achieved are not met, leading to a loss of support for environmental watering actions. Note - e-water deliveries may be constrained in 22-23 due to high consumptive avail.	Possible	Moderate	Medium	• Communications to inform the community on the limits of environmental water holdings and the extent of actions possible under dry conditions. *Note that public concern in this regard may be heightened as a result of the Menindee 2019 fish death events.*	CMA	Possible	Moderate	Medium	Medium
2019-20	Northern	Murray, Goulburn, Broken & Ovens	GBCMA & NECMA	NOGB2020-35	Environment	Limited environmental deliveries may reduce opportunities to test ecological responses to environmental flows, impacting on effectiveness of research projects.	Unlikely	Minor	Low	• Review monitoring program and adjust if possible. Reprioritise future flow targets.	CMA	Unlikely	Minor	Low	
2020-21	Northern	Murray, Goulburn, Broken & Ovens	GBCMA & NECMA	NOGB2021-36	Safety	Environmental releases create rapid or unexpected changes in flow conditions, resulting in injury to river users	Unlikely	Moderate	Low	• Include consideration of ramp-ups and ramp-down phases in release plans to reduce rapid water level changes. • Appropriate notification actions to alert general river users, especially for high use sites and high use periods. • Provide information on proposed changes to PV for inclusion in Change of Conditions Section of their website • Implement communications plan about environmental water releases - Undertake notifications to water users with assets potentially at risk due to changing river levels	CMA CMA CMA CMA GMW	Unlikely	Moderate	Low	

							Pre-Mitigation Risk					Residual Risk				
FY	Region	System	Waterway Manager	Risk ID	Risk category	Risk description	Likelihood	Consequence	Risk Rating	Mitigation actions	Lead organisn. for action	Likelihood	Consequence	Risk Rating	Remains medium/high after mitigation	Risk type Static or Dynamic
2019-20	Northern	North East	GBCMA & NECMA	NONE2020-38	Environment	Inability to accurately control small releases from both Lake Buffalo and Lake William Hovell limits the capacity to use CEWH water holdings to support base flows to provide critical drought refuge under dry conditions, resulting in failure to achieve desired environmental outcomes.	Unlikely	Minor	Low	• Initiate discussions with storage manager to identify desirable release rates and options for alternative release arrangements that could be implemented in dry periods	CMA	Unlikely	Minor	Low		Dynamic
2019-20	Northern	North East	GBCMA & NECMA	NONE2020-39	Environment	Stocking of wetlands with native fish may lead to a need to provide top-up deliveries, resulting in other priority environmental watering actions not being able to be undertaken	Unlikely	Minor	Low	• Complete an assessment of the viability of native fish stocking, including water availability under a range of climatic scenarios. • Undertake early planning and communications to investigate alternate water source for the wetland.	CMA / Land Manager	Unlikely	Minor	Low		Dynamic
2019-20	Northern	Barmah Forest	GBCMA & NECMA	NOBF2020-37	Reputational	Sections of the community perceive (incorrectly) that environmental water inundation concentrates feral horses (or other animals) into higher areas with insufficient feed, leading to concerns over animal cruelty or public safety risks if animals stray onto roads.	Likely	Minor	Low	• Implement feral horse management plan. • Monitor animal health condition and implement animal welfare actions as required. *Note: Need to check possible impact of feral horse control activities on ability to undertake environmental watering operations*	Land mgr.	Unlikely	Minor	Low		Dynamic
2020-21	All	All systems	All	NOGB2021-41	Safety	Negative community sentiment in relation to government decisions/actions creates a safety risk for staff involved in environmental watering actions **This is state wide risk, but may not apply in all systems - the risk rating will reflect local risk levels*	Possible	Moderate	Medium	- ensure staff are alerted to warnings about violent members of public - Strategic Communication of benefits of e-water and concern over safety to wider public (with co-ordination between partners) - ensure safe operational procedures for staff are followed	All	Possible	Moderate	Medium	Medium	Static
2021-22	Northern	Barmah Forest	GBCMA & NECMA	NOBF2022-43	Environment	Increased sedimentation in BMF waterways near offtake regulators results in reduction of delivery capacity into BMF and failure to achieve some environmental objectives	Possible	Minor	Low	- Develop desilting program to restore creek capacities	GMW/CMA	Possible	Minor	Low		Dynamic

10 Approval

I, Chris Cumming, the authorised representative of the agency shown below, approve the Seasonal Watering Proposal for the Barmah-Millewa Forest 2022-23.

SIGNED FOR AND ON BEHALF OF Goulburn Broken Catchment Management Authority

Signature of authorised representative

Name of authorised representative

Chris Cumming (CEO)

Date: 13 April 2022

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2022-23 SCBEWC Environmental Water Proposal: Barmah-Millewa Forest

Goulburn Broken Catchment Management Authority, Shepparton
NSW Office of Environment & Heritage, Albury

March 2022 – Stage 1 (15/03/2022)

SITE: Barmah-Millewa Forest

Stage 1: Proposed watering actions for the 2022-23 water year

Water Availability Scenario	Watering action description	Delivery Details					Return Flow (if available)			Can use unregulated? RMUF or Prior Rights / unreg license (Y / N / Both)	Any costs not included in existing budgets?	Key risks (incl environmental) associated with the watering action + mitigation measures
		Trigger flow (ML/d at a gauge or other trigger)	Vol (GL)	Inflow or target flow at a gauge (ML/d)	Duration (days, weeks or months)	Optimal timing & alternate (if flexible) (months)	Vol (GL)	Rate (ML/d)	Timing (months)			
All scenarios: Extreme Dry - 99% Very dry – 95% Dry – 90% Moderate – 75% Near av. – 50% Wet – 25%	**Action A: Translucent Regulators**. (supports BWS outcomes C1, F1, F2[1]) (supports BWS priority LP1)[2] Open most BM regulators in July/August before Murry River flows at Yarrawonga exceed 5,000 ML/d; and close in mid-December to permit river fluctuations to gradually connect and disconnect with those waterways as would have occurred under more natural conditions. Prevent MR fluctuations that exceed optimised Murray Cod spawning hydrograph (<±150mm/48hrs water level fluctuation in MRC from end Sept-mid Dec). Regulator closures would be provided in a sequence that can stimulate native fish exit from the forest as per the Millewa and Barmah fish exit strategies (in prep).	< 5,000 ML/d	Variable. Re-adopt BOC acceptance of 80% of diverted volume through BMF is returned and hence re-credited to e-water accounts.	Variable	5 mths	**Opt:** July to December **Alt:** September to October	-	-	-	N	N	**Risk: Regulator Opening Operation** Opening regulators when MR flows exceed 5,000 ML/d will have adverse impacts on vegetation, fish and geomorphology result of extreme water velocities. **Mitigation** Open BM regulators when MR flows < 5,000 ML/d **Risk: Regulator Closing Operation** Stranding of native fish behind BM forest regulators if closed abruptly. **Mitigation** NPWS and G-B CMA to finalise a native fish exit strategy aiming to mitigate stranding risk when regulators are closed. The exit strategy will then be incorporated into the BM native fish recovery plan. **Risk: Rush and gum invasion** Sustained low-level flooding could promote Giant Rush and/or Red Gum invasion on floodplain marsh / grassy wetlands (see Ecological Associates and Jane Roberts (2019)) **Mitigation** Create some variability in flow diversion with aim of a period of at least one month where additional floodplain depth can be created to drown any observed mass seedling events, even if this is at the expense of truncating ensuing flood duration.
Dry – 90% Moderate – 75% Near av. – 50% Wet – 25%	**Action B: Murray cod breeding.** Maintain flow within the main river channel at or above 8,500 ML/day in late-August through to December to support Murray cod nesting, survival and dispersal Avoid flow and water level oscillations that exceed ±150mm/48hrs during September to end-December period. [*intended just for in-channel and hence is bound by 8,500 to 9,200 ML/d, recognizing that this also caters for Cod breeding in Edwards River system*]	>8,500 ML/d	10GL - 60GL (flexible depending on water scenario – all flows less Translucent Flows remain in Murray) [*If the river falls to 8,000ML/d, then maintaining at 8,500ML/d*	8,500 ML/d (minimum target release from Yarrawonga).	4 mths	Late-Aug to Dec	0 ML/d (all flows to stay within Murray channel).	8,500 ML/d (minimum target release from Yarrawonga).	Late-Aug - Dec	No	No	**Risk**: **Oscillating water levels in MR forest creeks** Oscillating water levels during Murray cod breeding period cause disruption to spawning behaviours (courtship, nest selection, spawning success). **Mitigation:** Maintain stable water discharge and water levels to within 150mm/48hrs during Murray cod spawning period. Especially avoid rapid drops in water level in MR and forest creeks. **Risk**: **Hypoxic Blackwater** Floodplain inundation during summer causes development of hypoxic blackwater. **Mitigation** Floodplain inundation during winter/spring rather than summer. **Risk: Erosion** Bank-full MR flows to meet irrigation demand through spring-end summer causes bank slumping and erosion. **Mitigation**

[1] Refer to Appendix B for definition of codes used to describe Basin annual environmental watering outcomes as outlined in the technical report: https://www.mdba.gov.au/publications/mdba-reports/basin-annual-environmental-watering-priorities

[2] Refer to Appendix C for definition of codes used to describe Basin annual environmental watering priorities as outlined in the technical report: https://www.mdba.gov.au/publications/mdba-reports/basin-annual-environmental-watering-priorities

Water Availability Scenario	Watering action description	Delivery Details					Return Flow (if available)			Can use unregulated? RMUF or Prior Rights / unreg license (Y / N / Both)	Any costs not included in existing budgets?	Key risks (incl environmental) associated with the watering action + mitigation measures
		Trigger flow (ML/d at a gauge or other trigger)	Vol (GL)	Inflow or target flow at a gauge (ML/d)	Duration (days, weeks or months)	Optimal timing & alternate (if flexible) (months)	Vol (GL)	Rate (ML/d)	Timing (months)			
			for four months = 60GL]									Operate MR at lower than bank-full during summer-autumn.
All scenarios: Extreme Dry 99% Very dry – 95% Dry – 90% Moderate – 75% Near av. – 50% Wet – 25%	**Action C: Perch spawning pulses**. (supports BWS priority FP5) Create variability in water level in the main channel of the Murray River to facilitate spawning of native fish species, primarily Silver Perch. Up to three pulses may be required and will be managed through Barmah-Millewa OAG [*Also consider timing and subsequent re-magnification of MR flow pulse to d/s Torrumbarry with pulse from Goulburn R and Torrumbarry Weir pool. The aim is to cue juvenile golden perch dispersing from Menindee Lakes via LDR into MR to disperse upstream in MR. This element would be part of a broader multi-site watering action.* *See Sharpe and Stuart 2017 – Toward a Southern Connected flow plan for native fish https://www.mdba.gov.au/sites/default/files/pubs/Connecting-rivers-recover-native-fish-D17-22076.pdf*]	Any stable river levels if they occur for over two weeks without variability of +/- 150mm river level at Picnic Point (expected to be +/- 500 ML/d from Yarrawonga) while water temperature exceed 22ºC	0 ML *(to be delivered through management of river operations and not require environmental water*)	8,500 – 9,500 ML/d *(this action requires no extra water; achieved by varying operational flows +/- 150mm river level at Picnic Point (+/- 1000ML/d of Yarrawonga)*	2 - 6 days	Nov- Dec	0 ML/d (*flow remains in channel)*	6 days	Nov - Dec	N	N	**Risk** Reduced spawning activity for Silver Perch. Recent research indicates these species spawn in greater numbers in relation to specific characteristics in river levels and temperatures of 22ºC or more. **Mitigation** Ensure spawning pulses incorporated into watering plan
Extreme Dry 99% Very dry – 95%	**Action D: Critical drought refuge** (supports BWS priority WP6, FP5, FP15, FP24) Maintain critical drought refuges within Barmah - Millewa Forest with top-up flows to support refugia for fish, turtle, bird and veg populations in waterways and billabongs/lagoons that would be at risk of drying out. Waterways: Barmah: • Gulf Creek (MR flows >3,000 ML/d) • Boals Creek (MR flows >6,500 ML/d) Millewa: • Toupna Creek (MR flows >3,000 ML/d) • Gulpa Creek > 400 ML/d	>3,000 ML/d	Millewa: 0.3-0.5 GL per topping up event AND Barmah: 0.3-0.5 GL per topping up event	100 ML/d (each forest)	3-5 days	Timing will depend on water levels and water quality conditions within drought refuges (Nov – April)	-	-	-	N	Y (possibly need to have inflows gauged by hydrographer)	**Risks** • Desiccation of refugia for aquatic populations • Poor water quality including development of blue-green algae blooms and hypoxic blackwater if flow events occur in warmer months • Deliverability of flows to BM: Flows in MR are not sufficient to deliver water to drought refuges • Flows in Murray River are not sufficient to deliver water to drought refuges (depends on creek being targeted). **Mitigation** • Monitoring of drought refuges to prioritise water delivery interventions • Deliver water to maintain priority drought refuges • Undertake electrofishing to re-locate stranded fish • Work with River Ops to enable delivery. If not possible, undertake electrofishing and relocate fish/turtles.
Dry – 90% Moderate – 75% Near av. – 50%	**Action E: General drought refuge**. As per Action D + maintaining connectivity with main river channels where possible. (additionally supports BWS priority LP2, WP2, FP16, FP17) Freshen drought refuges within Barmah-Millewa Forest with summer/autumn freshes to support fish and turtle populations in waterways and billabongs/lagoons through improved water quality, increased food resources and to remove accumulated leaf litter and return carbon back to the main river channels.	>3,500 ML/d	Barmah: 6 – 12 GL per topping up event AND Millewa:	200 ML/d (for each of Barmah & Millewa t)	30 – 60 days (could involve up to four deliveries of two weeks duration or up to	Timing will depend on water levels and water quality conditions within drought refuges (Nov – April)	0 ML (return flows are expected but not measured)	-	-	N	Y (possibly need to have inflows gauged by hydrographer)	As per Action D plus **Key Risks** • Risk of hypoxic blackwater developing and reaching main river channel **Mitigation** • Water quality monitoring and adaptive management of flow event (evaluate based on river flows and the severity of the Blackwater. If hypoxic conditions develop, flows could either be ceased through the forest or maintained to flush and dilute Blackwater

Water Availability Scenario	Watering action description	Delivery Details					Return Flow (if available)			Can use unregulated? RMUF or Prior Rights / unreg license (Y / N / Both)	Any costs not included in existing budgets?	Key risks (incl environmental) associated with the watering action + mitigation measures
		Trigger flow (ML/d at a gauge or other trigger)	Vol (GL)	Inflow or target flow at a gauge (ML/d)	Duration (days, weeks or months)	Optimal timing & alternate (if flexible) (months)	Vol (GL)	Rate (ML/d)	Timing (months)			
	Waterways: Barmah: • Sandspit Creek (river flows >9,000 ML/d) • Gulf Creek (river flows >3,000 ML/d) • Punt Paddock Lagoon (river flows >8,000 ML/d) • Big Woodcutter Creek (river flows >7,500 ML/d • Boals Creek (river flows >6,500 ML/d) • Island Creek (river flows >7,500 ML/d) Millewa: • Toupna Creek (river flows >3,500 ML/d) • Pinchgut Lagoon (river flows >8,000 ML/d) • Nestrons (river flows >7500 ML/d) • Swifts and Bunnydigger creeks (river flows >7500 ML/day) • Reed Beds Swamp, Coppingers Swamp, Duck Lagoon and Horseshoe Lagoon (Gulpa Creek Offtake flows >500 ML/day) • St Helena and Black Swamp wetlands (Edward River Offtake flows >1000 ML/day		6 – 12 GL per topping up event		two deliveries of one-month duration depending on need. This will be managed through Barmah-Millewa OAG)							from the forest into the river (assuming river flows adequate to dilute the risk further downstream).
Dry – 90%	**Action F: Waterbird breeding/feeding (dry)** (supports BWS priority WP1, WP2) This action would sustain a waterbird breeding event by providing suitable conditions for successful breeding if nesting or calling activity indicates nesting has commenced. Australasian Bitterns are known to inhabit Barmah-Millewa wetlands during the breeding season with Boals Deadwoods, Moira Lake and Reed Beds all strongholds for bitterns in the area. This watering event will also help maintain health of reed beds required for nesting and improved feeding habitat for crakes, rails and Little Bitterns that are known to also use these wetlands. Wetlands: Barmah: Boals Deadwoods OR Millewa: Reed Beds Swamp	>6,500 ML/d (Boals Deadwoods) OR Gulpa Creek flow >500 ML/d (Reed Beds Swamp) OR River Murray flow >7500 ML/day (Moira Lake)	Barmah: 27 GL OR Reed Beds: 11 – 27 GL OR Moira Lake: 10 – 20 GL	Boals Deadwoods: 200 ML/d Reed Beds: >800 ML/d in early spring, dropping back to 500 over summer (250 ML/d is the base summer flow in the Gulpa Creek) Moira Lake: Fill Lake via Swifts, Bunnydigger and Moira Creek regulators during Sept 2019,	4.5 months (total time, but e-water would likely be a max of 3.5 months because nesting would have already started)	**Opt:** Sept – Feb (weather dependent. If colony hasn't established by mid-November this event will not progress)	-	-	-	N	Y (possibly need to have inflows gauged by hydrographer)	Do not deliver environmental watering if a nesting has not formed by mid-November. **Risk** • Insufficient environmental water volumes available to maintain adequate flood duration or depth to achieve successful chick fledging. **Mitigation** • Terminate event prior to egg stage if it becomes clear that insufficient water is available . **Risk** • Feral pig predation at nesting sites if water depth is too shallow (<0.5m). **Mitigation** • Increase daily water delivery volume to increase depth at the nesting colony to reduce the risk of pig predation on nests

Water Availability Scenario	Watering action description	Delivery Details					Return Flow (if available)			Can use unregulated? RMUF or Prior Rights / unreg license (Y / N / Both)	Any costs not included in existing budgets?	Key risks (incl environmental) associated with the watering action + mitigation measures
		Trigger flow (ML/d at a gauge or other trigger)	Vol (GL)	Inflow or target flow at a gauge (ML/d)	Duration (days, weeks or months)	Optimal timing & alternate (if flexible) (months)	Vol (GL)	Rate (ML/d)	Timing (months)			
				close regulators when Lake gauge level reaches 93.5m and top-up via Swifts and Bunnydigger when required (the gauge level is not to fall 30cm below the FSL for nesting bitterns).								
Moderate – 75% Near av. – 50%	**Action G: Waterbird breeding (moderate/near average)** (supports BWS priority WP3) As per Action F but with both Barmah AND Millewa wetlands Barmah: Boals Deadwoods AND Millewa: Reed Beds Swamp & Moira Lake	>6,500 ML/d (Boals Deadwoods) AND Gulpa Creek flow >500 ML/d (Reed Beds Swamp) AND River Murray flow >7500 ML/day (Moira Lake)	Barmah: 27 GL AND Reed Beds: 11 – 27 GL AND Moira Lake: 10 – 20 GL	Boals Deadwoods: 200 ML/d Reed Beds: >800 ML/d in early spring, dropping back to 500 over summer (250 ML/d is the base summer flow in the Gulpa Creek) Moira Lake: Fill Lake via Swifts, Bunnydigger and Moira Creek regulators during Sept	4.5 months (total time, but e-water would likely be a max of 3.5 months because nesting would have already started)	**Opt:** Sept – Feb (weather dependent. If colony hasn't established by mid-November this event will not progress)	-	-	-	N	Y (possibly need to have inflows gauged by hydrographer)	As per action F (Waterbird breeding -dry)

Water Availability Scenario	Watering action description	Delivery Details					Return Flow (if available)			Can use unregulated? RMUF or Prior Rights / unreg license (Y / N / Both)	Any costs not included in existing budgets?	Key risks (incl environmental) associated with the watering action + mitigation measures
		Trigger flow (ML/d at a gauge or other trigger)	Vol (GL)	Inflow or target flow at a gauge (ML/d)	Duration (days, weeks or months)	Optimal timing & alternate (if flexible) (months)	Vol (GL)	Rate (ML/d)	Timing (months)			
				2019, close regulators when Lake gauge level reaches 93.5m and top-up via Swifts and Bunnydigger when required (the gauge level is not to fall 30cm below the FSL for nesting bitterns).								
Wet – 25% Very Wet – 10%	**Action H: Waterbird breeding (wet)** As per Action G + additional wetlands (supports BWS priority WP4, WP5) Barmah: • Boals Deadwoods • Top Island • Reedy Lagoon (Keyes Point/Doctors Point) • Harbours Lake Millewa: • Reed Beds Swamp • Saint Helena • Black Swamp • Coppingers Swamp/Duck Lagoon • Moira Lake	>9,000 ML/d (Murray River) >1,900 ML/d (Edward River)	Barmah: 45 – 55 GL AND Millewa: 27.5 – 62.5 GL (a large proportion of this is expected to be provided by unregulated flows in a wet scenario)	Barmah 400 ML/d AND Millewa: 1000 ML/d	4.5 months (total time, but e-water would likely be a max of 3.5 months because nesting would have already started)	**Opt:** Sept – Feb (weather dependent. If colony hasn't established by mid-November this event will not progress)	-	-	-	N	Y (possibly need to have inflows gauged by hydrographer)	As per action F (Waterbird breeding -- moderate/near average)
Dry 90% Moderate 75% Near av. 50% Wet 25%	**Action I: Floodplain Marsh** (supports BWS priority VP11, VP12, VP13, VP14) Create conditions to promote growth and productivity and to restore seedbank of floodplain marsh vegetation communities on open plains wetlands. Create foraging grounds for birds, provide habitat for turtles and small-bodied native fish. Maintain stable, above channel capacity flows through from winter natural cues (peaks) into Spring where inundation can be increased to cover more floodplain in warmer conditions.	<15,000 ML/d (Oct to Nov) [*consider ability to deliver flows up to 18,000ML/d in September if agreement with Bullatale landholders can be achieved*]	Up to 500GL (a large proportion of this is expected to be provided by unregulated flows given high levels of supply due	Release from Yarrawonga to 15,000ML/d (or 18,000ML/d with Bullatale Ck landholder agreement(which	3 months	**Opt:** September – Nov **Alt:** Oct - Dec	Up to 400GL (80%)	Up to 7,200 ML/d	Sept – Nov	Y (RMUF)	N	**Risk** • Operational river level is too low to deliver this event, requiring very high daily use of environmental water delivery to reach 15,000 ML/d (or 18,000ML/d if Bullatale landholder agreement is achieved). **Mitigation** • Cease environmental water delivery if operational releases are below 8,000 ML/d for more than four days or below 9,000 ML/d for more than seven days **Risk** • MDBA River Operations require preferential diversion of bulk water through Barmah Forest due to

Water Availability Scenario	Watering action description	Delivery Details					Return Flow (if available)			Can use unregulated? RMUF or Prior Rights / unreg license (Y / N / Both)	Any costs not included in existing budgets?	Key risks (incl environmental) associated with the watering action + mitigation measures
		Trigger flow (ML/d at a gauge or other trigger)	Vol (GL)	Inflow or target flow at a gauge (ML/d)	Duration (days, weeks or months)	Optimal timing & alternate (if flexible) (months)	Vol (GL)	Rate (ML/d)	Timing (months)			
	Wetlands: Targeting Barmah Forest wetlands in spring 2022 (under the reciprocal alternating-year agreement) with some inundation of Millewa wetlands if river flows permit. Given full Murray R storages leading into 2022-23, relatively high winter-spring flows d/s Yarrawonga are predicted under most scenarios. Combined with high opening allocations, this action is likely to be achieved under a dry to wet scenario (typically average to wet) in 2022-23.		to large (100%) consumptive allocations for 2022-23– in a dry to wet scenario) + potentially additional water if 18,000ML/d for month of September is achievable	could be 6,000 – 9,000ML/d for up to 3 months depending on River Ops river level)								insufficient channel capacity to meet downstream demands. **Mitigation** • Swap proposed flooding of Millewa Forest for Barmah Forest to instead capitalize upon likely developing environmental outcomes in Barmah Forest as a result of the River Operations water division through the forest (e.g., sustain waterbird breeding events or achieve Floodplain Marsh flooding regime).
Wet – 25% Near av. – 50% Moderate 75%	**Action J: Autumn-winter perennial flow.** (supports BWS priority LP2, FP5, FP17, FP24) Improve flow conditions through main Millewa Forest waterways to provide additional channel refuge habitat and refine regulator operation to support juvenile fish spawned previous spring. Manage Murray River higher than winter operational flows at 4,000-6,000 ML/d to support fish habitats. Complement with elevated base flows in both Gulpa Creek (80-150 ML/d) and Edward River (600-800 ML/d). Open BMF regulators when Murray River flows d/s from Yarrawonga Weir are forecast by RMO to exceed 5,000 ML/day. This action cannot proceed without NPWS and Parks Victoria / Yorta Yorta support. Environmental water use will be calculated using the WLWG endorsed accounting method. In July, if Murray River flows are forecast by RMO to exceed 6,000 ML/day, then the flow rate may be increased up to 12,000 ML/day for up to 20 days duration (depending on environmental water availability). This action cannot proceed without NPWS and Parks Victoria / Yorta Yorta support. Waterways • Edward River • Gulpa Creek • Murray River • Toupna Creek (tbc) • Gulf Creek (tbc)	4,000 – 12,000 ML/d	10GL - 120 GL (flexible depending on water scenario)	4000 – 12000 ML/d (depending on scenari) downstream Yarrawonga	1 mth (July 2022) 2 mths (May – June 2023)	**Opt:** 1 mth (July 2022) 2 mths (May – June 2023)	10 GL - 120 GL (flexible depending on water scenario)	Na	1 mth (July 2022) 2 mths (May – June 2023)	Yes (RMUF)	N	**Risk: Insufficient volumes of environmental water to complete winter delivery schedule.** • Native fish recruitment potential is diminished by delivery of minimum WSP schedules **Mitigation** • Prioritise system(s) to receive environmental water in addition to WSP minimums **Risk** • Sustained low-level flooding could promote Giant Rush and/or Red Gum invasion on Barmah Lake (see Ecological Associates and Jane Roberts (2019)) **Mitigation** • Create some variability in flow diversion with aim of a period of at least one month where additional floodplain depth can be created to drown any observed mass seedling events, even if this is at the expense of truncating ensuing flood duration. If realistic, undertake manual removal of seedlings.

Stage 2: Alignment of watering actions with key site objectives and Basin Plan outcomes/priorities

Water availability scenario	Watering action description	Short description of site/reach-based objectives that this action will contribute to (include references)	Alignment with Basin Plan Environmental Management Framework			Linkage to recent watering history and/or consideration of inter-annual watering needs.
			Alignment with Matter 9.3 primary purpose (see Appendix B)	Alignment with Matter 9.3 rolling, multi-year priority (see Appendix C)	Further information on how the watering action aligns with the Environmental Management Framework and Long-term watering plans (LTWPs)	
All	**Action A:** Translucent Regulators	Open most BM regulators in July and close in late-December (subject to seasonal conditions), irrespective of river level, to permit river fluctuations to gradually connect and disconnect with those waterways as would have occurred under more natural conditions.	River flows & Connectivity • Longitudinal Connectivity within flood runners and Lateral Connectivity: increase in lowland floodplain flows (C2). Vegetation - Forests and woodlands (river red gum) • No decline in the condition of river red gum (V2) Fish • No loss of native species, improved population structure, increased movement and expanded distribution of key species and populations. (F1)	1a-e. Flow Connectivity • Support lateral and longitudinal connectivity along the river systems 3a-e Vegetation • Allow opportunities for growth of non-woody wetland vegetation. 5a-e Vegetation Maintain the extent, improve the condition and promote recruitment of forests and woodlands. 7a-e Vegetation Expand the extent and improve the condition of Moira grass in Barmah–Millewa Forest. 9a-e Waterbirds • Maintain the diversity and improve the abundance of the Basin's waterbird population 11. Native Fish (all scenarios) • Support Basin-scale population recovery of native fish by reinstating flows that promote key ecological processes across local, regional and system scales in the southern connected Basin	This watering action will provide early flows into Barmah and Millewa, which trigger flows to flow through the forest in the cooler months, providing an opportunity for leaf litter to be flushed prior to warmer water temperatures. The duration enables water-dependent species to establish and complete life cycles.	Translucent regulator operation is becoming 'business as usual' after being successfully trialled each year snice 2017-18. By providing the opportunity for floodplain drainage lines to rise and fall with the river height, the peak of the winter flow event passed through the forest naturally. Efficiencies were improved by leaving regulators open across the season, saving resources and producing better ecological responses. Improvements in ecological response were due to better connectivity across wetlands and floodplain communities, velocities which favoured cod habitat requirements throughout the cod breeding and spawning season, and it encouraged better nutrient cycling and productivity increases through plant growth.
All	**Action B:** Murray Cod breeding	Will support nesting, survival and dispersal of Murray Cod by ensuring flows do not fall below 8,500 ML/day in late-August through to December and water level oscillations do not exceed ±150mm/48hrs during September to end-December period. *[Koehn et al (2020) A compendium of ecological knowledge for restoration of freshwater fishes in Australia's Murray–Darling Basin. Marine and Freshwater Research, 71: 1391–1463.]* *[Tonkin et al (2021) Linking flow attributes to recruitment to inform water management for an Australian freshwater fish with an equilibrium life-history strategy. Science of the Total Environment 752 ttps://doi.org/10.1016/j.scitotenv.2020.141863]*	River flows & Connectivity • Longitudinal connectivity: improve longitudinal connections along rivers and between rivers. (C1) Fish • Broad outcomes: No loss of native species, improved population structure, increased movement and expanded distribution of key species and populations. (F1) • Moderate to long-lived species: improved population structure in key sites; 10–15% increase of mature fish (of legal take size) for recreational target species (Murray cod and golden perch) in key populations; and annual detection of species and life stages representative of the whole fish community through fish passages. (F3) Distribution of key species: significant increases in the distributions of key species in the southern Basin. (F6)	Connectivity • Coordinate environmental watering to increase longitudinal connectivity in connected catchments. Mitigate irreversible impacts associated with extended drought. (LP1) • Prevent dry spell durations exceeding refuge tolerances. Provide replenishment flows to maintain habitat condition and regulate water quality, carbon and nutrients. (LP2) • Coordinate regulated releases with tributary flows (regulated and unregulated) to increase longitudinal connectivity in the Barwon–Darling and Murray rivers. Coordinate regulated releases with timing of tributary flow events to increase flow variability and the frequency of in-channel pulses and bankfull flow events. Extend the duration and magnitude of natural events to promote the movement of biota nutrients, sediments and salt. (LP3) • Manage water in harmony with natural cues to maximise connectivity and flow variability to reinstate key elements of the flow regime. Provide flow regimes that	This watering action will ensure water levels and rate of fluctuations remain adequate to ensure continued nesting of Murray Cod during their spawning season. This supports the BM Environmental Watering Plan (MDBA 2012) fish objective of supporting successful breeding and recruitment of native fish species by promote successful recruitment of native fish species by improving flow targets under variability in spring and early summer to replicate natural cues.	Without the proposed intervention of minimum flow and rate of fluctuations in river level, flows have fallen too rapidly by reducing releases from Yarrawonga at maximum rates following the passing of a natural flow pulse or reduction in irrigation demand. Tempering the rates of decline during the Murray Cod nesting season will favour cod nesting requirements.

Water availability scenario	Watering action description	Short description of site/reach-based objectives that this action will contribute to (include references)	Alignment with Basin Plan Environmental Management Framework			Linkage to recent watering history and/or consideration of inter-annual watering needs.
			Alignment with Matter 9.3 primary purpose (see Appendix B)	Alignment with Matter 9.3 rolling, multi-year priority (see Appendix C)	Further information on how the watering action aligns with the Environmental Management Framework and Long-term watering plans (LTWPs)	
				allow opportunities for high ecological productivity. Supplement unregulated flow events to promote hydraulic diversity and facilitate natural geomorphic processes and groundwater replenishment. (LP4) Fish • Recruitment objective: Support local recruitment in the main channel of the River Murray and lower Darling River, and regulated anabranches and tributaries. (FP1) • Provide base flows, low flows and small freshes. (FP5) • Increase flow connections between major rivers and their tributaries and anabranches to promote movement and dispersal. (FP13) • Provide flows that protect ecologically important populations of native fish. (FP14) • Provide flows that maintain existing populations. Provide base flows, low flows and small freshes which support hydrological connectivity within and between systems. (FP16) • Provide flows that support connectivity among populations and chances for fish to disperse. (FP17) • Increase flow connections between major rivers and their tributaries and anabranches to promote movement and dispersal. (FP23)		
All	**Action C:** Perch spawning pulses	Create variability in water level in the main channel of the Murray River to facilitate spawning of native fish species, primarily Silver Perch. Up to three pulses may be required. Coordinate flow pulses with tributary events to maximise opportunity for immigration of golden perch juveniles into the BM reach from potential dispersal events sourced from Menindee Lakes and lower Darling in 2021/22. Coordination will be managed through Barmah-Millewa OAG.	River flows & Connectivity • Longitudinal connectivity: improve longitudinal connections along rivers and between rivers. (C1) Fish • Broad outcomes: No loss of native species, improved population structure, increased movement and expanded distribution of key species and populations. (F1)	Fish • Support system-scale migrations of golden perch, silver perch and lamprey. (FP10) • Maintain the integrity of spawning flow pulses to allow eggs and larvae to drift uninterrupted. (FP11) • Provide opportunities for young golden perch and silver perch to disperse following episodic system-scale recruitment events. (FP12)	The watering action involves creating some flow variability in the main channel of the Murray River in spring and early summer to replicate natural cues, and by inundation of floodplain and wetland areas to provide breeding and nursery habitat.	This watering action has in recent years become 'business as usual' given that it can often be achieved without need for specific environmental water allocations (by adopting a temporary lowering of river releases followed by a temporary raising or river releases by River Operations to result in a small variation in river level with neutral water loss). Therefore, this watering action is anticipated to be provided on an ongoing basis into the future, with some refinement of management responses as further learning occurs.
Very Dry, Dry	**Action D:** Critical drought refuge	Maintain critical drought refuges within Barmah - Millewa Forest with spring/summer/autumn freshes to support fish and turtle populations in waterways and billabongs/lagoons that would be at risk of drying out. Waterways: Barmah: • Gulf Creek (river flows >3,000 ML/d) • Boals Creek (river flows >6,500 ML/d) Millewa:	River flows & Connectivity • Lateral Connectivity: increase frequency of freshes, bank-full and lowland floodplain flows. (C2) Fish • Broad outcomes: No loss of native species, improved population structure, increased movement and expanded distribution of key species and populations. (F1)	Connectivity • Coordinate environmental watering to increase longitudinal connectivity in connected catchments. Mitigate irreversible impacts associated with extended drought. Prevent dry spell durations exceeding refuge tolerances. (LP1) Moira grass • Where possible, limit any loss of Moira grass extent through the operation of forest regulators. The necessity of this action will become	The watering action focuses on improving lateral connectivity to contribute to BWS outcomes for native fish. It will maintain critical drought refuges within Barmah-Millewa Forest in spring, summer and autumn if very dry conditions occur that would threaten to desiccate such important habitat areas. During the millennium drought permanent waterbodies within Barmah-Millewa Forest dried out causing widespread deaths of turtles and fish. This environmental watering action aims to prevent this from happening again and continue the recovery of turtle and fish populations following the drought.	This watering action is only required if critical drought refuges are threatened with drying if weather conditions are very dry during the year. Relatively small volumes of water will be required on an 'as needed' basis.

Water availability scenario	Watering action description	Short description of site/reach-based objectives that this action will contribute to (include references)	Alignment with Basin Plan Environmental Management Framework			Linkage to recent watering history and/or consideration of inter-annual watering needs.
			Alignment with Matter 9.3 primary purpose (see Appendix B)	Alignment with Matter 9.3 rolling, multi-year priority (see Appendix C)	Further information on how the watering action aligns with the Environmental Management Framework and Long-term watering plans (LTWPs)	
		• Toupna Creek (river flows >3,500 ML/d)		more critical the longer the preceding dry spell (VP11) Fish • Provide flows that protect ecologically important populations of native fish. (FP14)		
Very Dry, Dry Moderate Nr Average	**Action E:** General drought refuge	As per Action C + maintaining connectivity with main river channels where possible. Waterways: Barmah: • Sandspit Creek (river flows >9,000 ML/d) • Gulf Creek (river flows >3,000 ML/d) • Punt Paddock Lagoon (river flows >8,000 ML/d) • Big Woodcutter Creek (river flows >7,500 ML/d • Boals Creek (river flows >6,500 ML/d) • Island Creek (river flows >7,500 ML/d) Millewa: • Toupna Creek (river flows >3,500 ML/d) • Pinchgut Lagoon (river flows >8,000 ML/d) • Nestrons (river flows >7500 ML/d) • Swifts and Bunnydigger creeks (river flows >7500 ML/day) • Reed Beds Swamp, Coppingers Swamp, Duck Lagoon and Horseshoe Lagoon (Gulpa Creek Offtake flows >500 ML/day) • St Helena and Black Swamp wetlands (Edward River Offtake flows >1000 ML/day)	River flows & Connectivity • Lateral Connectivity: increase frequency of freshes, bank-full and lowland floodplain flows. (C2) Fish • Broad outcomes: No loss of native species, improved population structure, increased movement and expanded distribution of key species and populations. (F1)	Connectivity • Provide replenishment flows to maintain habitat condition and regulate water quality, carbon and nutrients. (LP2) Waterbirds • Maintain foraging and roosting habitat at refuge locations. Support breeding where naturally triggered. (dry) (WP2) Fish • Provide flows that protect ecologically important populations of native fish. (FP14)	As per Action C (above) except that the intended flow will occur for longer to reconnect waterway discharge back to the river and thereby increase the area and access to areas of good water quality available for fish. This action will freshen drought refuges within Barmah-Millewa Forest with summer/autumn freshes to support fish and turtle populations in waterways and billabongs/lagoons through improved water quality, increased food resources and to remove accumulated leaf litter and return carbon back to the main river channels.	As per Action C (above) except greater volumes of water will be sought to maintain through flow in the waterways. The action is not dependent upon continual supply or repeat waterings, as "anything is better than nothing" when it comes to providing some flushing flows through the forests' waterways.
Very Dry Dry	**Action F:** Waterbird breeding (dry)	This action aims to sustain a waterbird breeding event by providing suitable conditions for successful breeding if nesting or calling activity indicates nesting has commenced. Wetlands: Barmah: Boals Deadwoods OR Millewa: Reed Beds	River flows & Connectivity • Lateral Connectivity: increase frequency of freshes, bank-full and lowland floodplain flows. (C2) Waterbirds • Number and type of waterbird species present in the Basin will not fall below current observations (WB1) • Significant improvement in waterbird populations (WB2) • Breeding events (the opportunities to breed rather than the magnitude of breeding per se) of colonial nesting waterbirds to increase by up to 50% compared to the baseline scenario (WB3)	Waterbirds • Maintain foraging and roosting habitat at refuge locations. Support breeding where naturally triggered. (WP2)	Waterbirds were known to breed most years in Barmah-Millewa Forest prior to river regulation and now the frequency and magnitude of waterbird breeding events has declined significantly. Australasian Bitterns are known to inhabit Barmah-Millewa wetlands during the breeding season, and Moira Lake, Reed Beds and Boals Deadwood are both strongholds for bitterns in the area. This watering event will also help maintain health of reed beds required for nesting and improved feeding habitat for crakes, rails and Little Bitterns that are known to use these wetlands. It will also test whether a successful, meaningful breeding event can be achieved with minimal inundation of surrounding floodplain (in a dry scenario).	Providing an annual wetting and drying cycle will help improve the quality of vegetation present and maintain the mosaic of giant rush which is optimal for waterbird breeding.
Moderate Nr Average	**Action G:** Waterbird breeding	As per Action F with both Barmah **AND** Millewa wetlands Wetlands:	As per Action F	Waterbirds • Maintain waterbird breeding habitat in 'event ready' condition. Trigger and provide ongoing support for	As per Action F (above) except that a wetland in <u>both</u> Barmah and Millewa Forest will be targeted for water delivery given higher water resource availability.	Creating water depths that are deep enough to exclude predators will ensure that waterbirds get a better opportunity to have a productive and successful breeding season. In 2017/18,

Water availability scenario	Watering action description	Short description of site/reach-based objectives that this action will contribute to (include references)	Alignment with Basin Plan Environmental Management Framework			Linkage to recent watering history and/or consideration of inter-annual watering needs.
			Alignment with Matter 9.3 primary purpose (see Appendix B)	Alignment with Matter 9.3 rolling, multi-year priority (see Appendix C)	Further information on how the watering action aligns with the Environmental Management Framework and Long-term watering plans (LTWPs)	
	(moderate/near average)	Barmah: Boals Deadwoods AND Millewa: Reed Beds		small-scale breeding across functional groups. Support breeding where naturally triggered. Create mosaic of wetland habitats suitable for functional feeding groups. (WP3)	This will make a greater contribution to achieving BWS outcomes for waterbirds due to the increased scale of watering (area of habitat available and access to food resources) and likelihood of natural cues that trigger breeding to occur.	waterbirds invested energy into nesting and laying eggs but nests were predated by exotic animals (pigs) and this will be avoided in the future through optimised pest management and water management.
Wet	**Action H:** Waterbird breeding (wet)	Action F & G + additional wetlands Barmah: • Boals Deadwoods • Top Island • Reedy Lagoon (Keyes Point/Doctors Point) Harbours Lake Millewa: • Reed Beds • Saint Helena • Black Swamp • Coppingers Swamp/Duck Lagoon • Moira Lake • Walthours Swamp	As per Action G	Waterbirds • Support breeding where naturally triggered. Create mosaic of wetland habitats suitable for functional feeding groups. Trigger and provide ongoing support for small to moderate-scale breeding across functional groups (WP4)	A wet scenario is likely to induce waterbird breeding across many wetlands in Barmah-Millewa. By inundating a variety of wetlands with varying characteristics, a greater diversity of waterbird species is likely to have the opportunity to breed. With more water in the system, we can also expect a greater abundance of waterbirds breeding, which potentially improve waterbird populations significantly.	In the past, wet conditions often lead to waterbirds self-initiating breeding so it would be prudent to plan for the need for environmental water to sustain any self-initiated nesting to ensure that a productive breeding season is achieved. Achievement of the desired objective is high given past experience.
Nr average Wet	**Action I: Floodplain marsh**	Maintain stable, above channel capacity flows through the forest from winter natural cues (peaks) into spring where inundation can be increased to cover more floodplain in warmer conditions. Targeting Barmah Forest wetlands in spring 2022 (under the reciprocal alternating-year agreement) with some inundation of Millewa wetlands if river flows permit.	River flows & Connectivity • Lateral Connectivity: increase frequency of freshes, bank-full and lowland floodplain flows. (C2) Water dependent vegetation • Maintain extent of non-woody vegetation and by 2024 increased periods of growth. (V6) Waterbirds • Number and type of waterbird species present in the Basin will not fall below current observations. (WB1) • Significant improvement in waterbird populations. (WB2) • Breeding events (the opportunities to breed rather than the magnitude of breeding per se) of colonial nesting waterbirds to increase by up to 50% compared to the baseline scenario. (WB3) Fish • Broad outcomes: No loss of native species, improved population structure, increased movement and expanded distribution of key species and populations. (F1)	Moira grass • Improve the condition and maintain the extent of Moira grass by providing an opportunity for growth of existing plants. Where possible, aim to improve the extent by providing inundation in line with optimal duration and flooding. (VP13) • Improve the condition and extent of Moira grass by providing inundation in line with optimal duration and timing. If a flowering event occurred in the previous water year, promote seed germination if/where possible. If seed germination occurred in the previous water year, support the consolidation of growth of new plants. (VP14) Waterbirds • Create a mosaic of wetland habitats suitable for functional feeding groups. (WP3/WP4)	Create conditions to promote growth and productivity and to restore seedbank of floodplain marsh vegetation communities on open plains wetlands. Create foraging grounds for birds, provide habitat for turtles and small-bodied native fish.	Improvements in water-dependent plant coverage in open, low-lying floodplain areas will improve with further watering in coming years. Connecting drainage lines and wetland/lakes system provides an opportunity for fish to move and utilise the resources available. Tagged fish in the system moving through regulating structure may provide more information on how our native fish are utilising these habitats.
Wet, Near-average and Moderate	**Action J:** Autumn-winter perennial flows	Improve flow conditions through main Millewa Forest waterways to provide additional channel refuge habitat and refine regulator operation to support juvenile fish spawned previous spring. Manage Murray River higher than winter operational flows at 4,000-6,000 ML/d to	River flows & Connectivity • Lateral Connectivity: increase frequency of freshes, bank-full and lowland floodplain flows. (C2) Fish • Broad outcomes: No loss of native species, improved population structure, increased movement and	Fish • Provide flows that protect ecologically important populations of native fish. (FP14)	This watering action will provide additional channel refuge habitat and refine regulator operation to support juvenile fish spawned previous spring. This supports the BM Environmental Watering Plan (MDBA 2012) fish objective of supporting successful breeding and recruitment of native fish species.	Without the proposed intervention of minimum flow and rate to provide additional channel refuge habitat, cease to flow conditions are likely to occur which could result in death of juvenile native fish spawned previous spring.

Water availability scenario	Watering action description	Short description of site/reach-based objectives that this action will contribute to (include references)	Alignment with Basin Plan Environmental Management Framework			Linkage to recent watering history and/or consideration of inter-annual watering needs.
			Alignment with Matter 9.3 primary purpose (see Appendix B)	Alignment with Matter 9.3 rolling, multi-year priority (see Appendix C)	Further information on how the watering action aligns with the Environmental Management Framework and Long-term watering plans (LTWPs)	
		support fish habitats. Complement with elevated base flows in both Gulpa Creek (80-150 ML/d) and Edward River (600-800 ML/d). Open BMF regulators when Murray River flows d/s from Yarrawonga Weir are forecast by RMO to exceed 5,000 ML/day. This action cannot proceed without NPWS and Parks Victoria / Yorta Yorta support. Environmental water use will be calculated using the WLWG endorsed accounting method. In July, if Murray River flows are forecast by RMO to exceed 6,000 ML/day, then the flow rate may be increased up to 12,000 ML/day for up to 20 days duration (depending on environmental water availability). This action cannot proceed without NPWS and Parks Victoria / Yorta Yorta support. Waterways • Edward River • Gulpa Creek • Murray River • Toupna Creek (tbc) • Gulf Creek (tbc)	expanded distribution of key species and populations. (F1)			

Appendix B – Basin Plan Matter 9.3 primary purposes

Adheres to requirements and terminology of annual reporting under Matter 9.3 of Schedule 12 of the Basin Plan (Commonwealth of Australia 2012)

Primary purpose
Longitudinal connectivity
Lateral connectivity
End of Basin Flows
Vegetation - Forests and woodlands (river red gum, black box, coolibah etc.)
Vegetation - Shrublands (lignum shrubland etc.)
Vegetation - Ruppia tuberosa
Vegetation - Riparian
Vegetation - Non woody (Moira grass, common reed, cumbungi, water couch, marsh club-rush etc.)
Waterbirds
Fish
Water quality (Physico-chemical)
Ecosystem processes (e.g. carbon and nutrient cycling)
Other (e.g. resilience, ecosystem diversity)

Appendix C - Basin Plan Matter 9.3 rolling, multi-year priorities

Adheres to requirements and terminology of annual reporting under Matter 9.3 of Schedule 12 of the Basin Plan (Commonwealth of Australia 2012)

Rolling, multi-year priority
FLOW
1a. FLOW: (VERY DRY) Support lateral and longitudinal connectivity along the river systems.
1b. FLOW: (DRY) Support lateral and longitudinal connectivity along the river systems.
1c. FLOW: (MODERATE) Support lateral and longitudinal connectivity along the river systems.
1d. FLOW: (WET) Support lateral and longitudinal connectivity along the river systems.
1e. FLOW: (VERY WET) Support lateral and longitudinal connectivity along the river systems.
2a. FLOW: (VERY DRY) Support freshwater connectivity through the Lower Lakes, Coorong and Murray Mouth.
2b. FLOW: (DRY) Support freshwater connectivity through the Lower Lakes, Coorong and Murray Mouth.
2c. FLOW: (MODERATE) Support freshwater connectivity through the Lower Lakes, Coorong and Murray Mouth.
2d. FLOW: (WET) Support freshwater connectivity through the Lower Lakes, Coorong and Murray Mouth.
2e. FLOW: (VERY WET) Support freshwater connectivity through the Lower Lakes, Coorong and Murray Mouth.
VEGETATION
3a. VEGETATION: (VERY DRY) Allow opportunities for growth of non-woody wetland vegetation.
3b. VEGETATION: (DRY) Allow opportunities for growth of non-woody wetland vegetation.
3c. VEGETATION: (MODERATE) Allow opportunities for growth of non-woody wetland vegetation.
3d. VEGETATION: (WET) Allow opportunities for growth of non-woody wetland vegetation.
3e. VEGETATION: (VERY WET) Allow opportunities for growth of non-woody wetland vegetation.
4a. VEGETATION: (VERY DRY) Allow opportunities for growth of non-woody riparian vegetation that closely fringes or occurs within main river corridors.
4b. VEGETATION: (DRY) Allow opportunities for growth of non-woody riparian vegetation that closely fringes or occurs within main river corridors.
4c. VEGETATION: (MODERATE) Allow opportunities for growth of non-woody riparian vegetation that closely fringes or occurs within main river corridors.
4d. VEGETATION: (WET) Allow opportunities for growth of non-woody riparian vegetation that closely fringes or occurs within main river corridors.
4e. VEGETATION: (VERY WET) Allow opportunities for growth of non-woody riparian vegetation that closely fringes or occurs within main river corridors.
5a. VEGETATION: (VERY DRY) Maintain the extent, improve the condition and promote recruitment of forests and woodlands.
5b. VEGETATION: (DRY) Maintain the extent, improve the condition and promote recruitment of forests and woodlands.
5c. VEGETATION: (MODERATE) Maintain the extent, improve the condition and promote recruitment of forests and woodlands.
5d. VEGETATION: (WET) Maintain the extent, improve the condition and promote recruitment of forests and woodlands.
5e. VEGETATION: (VERY WET) Maintain the extent, improve the condition and promote recruitment of forests and woodlands.
6a. VEGETATION: (VERY DRY) Maintain the extent and improve the condition of lignum shrublands.
6b. VEGETATION: (DRY) Maintain the extent and improve the condition of lignum shrublands.
6c. VEGETATION: (MODERATE) Maintain the extent and improve the condition of lignum shrublands.
6d. VEGETATION: (WET) Maintain the extent and improve the condition of lignum shrublands.
6e. VEGETATION: (VERY WET) Maintain the extent and improve the condition of lignum shrublands.
7a. VEGETATION: (VERY DRY) Expand the extent and improve the condition of Moira grass in Barmah–Millewa Forest.
7b. VEGETATION: (DRY) Expand the extent and improve the condition of Moira grass in Barmah–Millewa Forest.
7c. VEGETATION: (MODERATE) Expand the extent and improve the condition of Moira grass in Barmah–Millewa Forest.
7d. VEGETATION: (WET) Expand the extent and improve the condition of Moira grass in Barmah–Millewa Forest.
7e. VEGETATION: (VERY WET) Expand the extent and improve the condition of Moira grass in Barmah–Millewa Forest.
8a. VEGETATION: (VERY DRY) Expand the extent and improve resilience of ruppia in the southern Coorong.
8b. VEGETATION: (DRY) Expand the extent and improve resilience of ruppia in the southern Coorong.
8c. VEGETATION: (MODERATE) Expand the extent and improve resilience of ruppia in the southern Coorong.
8d. VEGETATION: (WET) Expand the extent and improve resilience of ruppia in the southern Coorong.
8e. VEGETATION: (VERY WET) Expand the extent and improve resilience of ruppia in the southern Coorong.
WATERBIRDS

9a. WATERBIRDS: (VERY DRY) Maintain the diversity and improve the abundance of the Basin's waterbird population. **Basin significant sites:** Corop wetlands, Fivebough Swamp*, Lowbidgee Floodplain, Pyap Lagoon, River Murray & Euston Lakes, Upper Darling River, Lower Lakes, Coorong and Murray Mouth Core marsh areas can also act as drought refuges.
9b. WATERBIRDS: (DRY) Maintain the diversity and improve the abundance of the Basin's waterbird population. **Basin significant sites:** Barmah-Millewa*, Booligal wetlands, Lower Lakes, Coorong & Murray Mouth*, Corop wetlands (refuge), Fivebough Swamp* (refuge), Great Cumbung Swamp, Gunbower-Koondrook–Perricoota*, Gwydir wetlands*, Hattah Lakes*, Kerang wetlands*, Lake Brewster, Lowbidgee Floodplain (refuge), Macquarie Marshes*, Narran Lakes*, Pyap Lagoon (refuge), River Murray & Euston Lakes (refuge), Upper Darling River (refuge)
9c. WATERBIRDS: (MODERATE) Maintain the diversity and improve the abundance of the Basin's waterbird population. **Basin significant sites:** Barmah-Millewa*, Booligal wetlands, Lower Lakes, Coorong & Murray Mouth*, Corop wetlands, Great Cumbung Swamp, Gunbower–-Koondrook–Perricoota*, Gwydir wetlands*, Hattah Lakes*, Kerang wetlands*, Lake Brewster, Lowbidgee Floodplain, Macquarie Marshes*, Narran Lakes*, Pyap Lagoon
9d. WATERBIRDS: (WET) Maintain the diversity and improve the abundance of the Basin's waterbird population. **Basin significant sites:** Barmah-Millewa*, Booligal wetlands, Lower Lakes, Coorong & Murray Mouth*, Corop wetlands, Darling Anabranch, Fivebough Swamp*, Great Cumbung Swamp, Gunbower–Koondrook–Perricoota*, Gwydir wetlands*, Hattah Lakes*, Kerang wetlands*, Lake Brewster, Lake Buloke, Lindsay–Walpolla–Chowilla*, Lowbidgee Floodplain, Macquarie Marshes*, Narran Lakes*, Pyap Lagoon, River Murray & Euston Lakes
9e. WATERBIRDS: (VERY WET) Maintain the diversity and improve the abundance of the Basin's waterbird population. **Basin significant sites:** Barmah-Millewa*, Booligal wetlands, Lower Lakes, Coorong & Murray Mouth*, Corop wetlands, Darling Anabranch, Fivebough Swamp*, Great Cumbung Swamp, Gunbower–Koondrook–Perricoota*, Gwydir wetlands*, Hattah Lakes*, Kerang wetlands*, Lake Brewster, Lake Buloke, Lindsay–Walpolla–Chowilla*, Lowbidgee Floodplain, Macquarie Marshes*, Narran Lakes*, Pyap Lagoon, River Murray & Euston Lakes
10a. WATERBIRDS: (VERY DRY) Maintain the abundance of key shorebird species in the Lower Lakes and Coorong.
10b. WATERBIRDS: (DRY) Maintain the abundance of key shorebird species in the Lower Lakes and Coorong.
10c. WATERBIRDS: (MODERATE) Maintain the abundance of key shorebird species in the Lower Lakes and Coorong.
10d. WATERBIRDS: (WET) Maintain the abundance of key shorebird species in the Lower Lakes and Coorong.
10e. WATERBIRDS: (VERY WET) Maintain the abundance of key shorebird species in the Lower Lakes and Coorong.
NATIVE FISH
11-. NATIVE FISH: (ALL SCENARIOS): Support Basin-scale population recovery of native fish by reinstating flows that promote key ecological processes across local, regional and system scales in the southern connected Basin.
11a. NATIVE FISH (VERY DRY): Support Basin-scale population recovery of native fish by reinstating flows that promote key ecological processes across local, regional and system scales in the southern connected Basin.
11b. NATIVE FISH: (DRY) Support Basin-scale population recovery of native fish by reinstating flows that promote key ecological processes across local, regional and system scales in the southern connected Basin.
11c. NATIVE FISH: (MODERATE) Support Basin-scale population recovery of native fish by reinstating flows that promote key ecological processes across local, regional and system scales in the southern connected Basin.
11d. NATIVE FISH: (WET) Support Basin-scale population recovery of native fish by reinstating flows that promote key ecological processes across local, regional and system scales in the southern connected Basin.
11e. NATIVE FISH: (VERY WET) Support Basin-scale population recovery of native fish by reinstating flows that promote key ecological processes across local, regional and system scales in the southern connected Basin.
12-. NATIVE FISH: (ALL SCENARIOS) Improve flow regimes and connectivity in northern Basin rivers to support native fish populations across local, regional and system scales.
12a. NATIVE FISH: (VERY DRY) Improve flow regimes and connectivity in northern Basin rivers to support native fish populations across local, regional and system scales.
12b. NATIVE FISH: (DRY) Improve flow regimes and connectivity in northern Basin rivers to support native fish populations across local, regional and system scales.
12c. NATIVE FISH: (MODERATE) Improve flow regimes and connectivity in northern Basin rivers to support native fish populations across local, regional and system scales.
12d. NATIVE FISH: (WET) Improve flow regimes and connectivity in northern Basin rivers to support native fish populations across local, regional and system scales.
12e. NATIVE FISH: (VERY WET) Improve flow regimes and connectivity in northern Basin rivers to support native fish populations across local, regional and system scales.
13-. NATIVE FISH: (ALL SCENARIOS) Support viable populations of threatened native fish, maximise opportunities for range expansion and establish new populations.
13a. NATIVE FISH: (VERY DRY) Support viable populations of threatened native fish, maximise opportunities for range expansion and establish new populations.

13b. NATIVE FISH: (DRY) Support viable populations of threatened native fish, maximise opportunities for range expansion and establish new populations.
13c. NATIVE FISH: (MODERATE) Support viable populations of threatened native fish, maximise opportunities for range expansion and establish new populations.
13d. NATIVE FISH: (WET) Support viable populations of threatened native fish, maximise opportunities for range expansion and establish new populations.
13e. NATIVE FISH: (VERY WET) Support viable populations of threatened native fish, maximise opportunities for range expansion and establish new populations.
0. No alignment; see primary and additional purposes