Broken River and Upper Broken Creek Seasonal Watering Proposal 2024-2025

GOULBURN BROKEN CATCHMENT MANAGEMENT AUTHORITY

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Document Control

STATUS	VERSION	AUTHOR	DATE	DESCRIPTION
Template	1.0	Ashley Macqueen	21/11/2023	Prepopulated content incorporated into template ready for issue to CMA.
Draft	1.1	Simon Casanelia	1/03/2024	Draft proposal
Final	1.2	Simon Casanelia	15/04/2024	Final proposal incorporating feedback from VEWH, PV, CEWH and YYNAC

1 CONTEXT

This Seasonal Watering Proposal (SWP) outlines the Goulburn Broken Catchment Management Authority's (GB CMA) priorities for the use of environmental water for delivery to the Broken River and upper Broken Creek during 2024-2025 to protect and enhance their environmental values and health.

The purpose of this proposal is to:

- identify the environmental water requirements of the Broken River and upper Broken Creek in the coming year under a range of climate scenarios to protect or improve their environmental values and health; and
- inform the development of environmental watering actions in the VEWH's seasonal watering plan.

The proposal is informed by scientific studies and reports that identify the flow regimes required to meet the ecological objectives of the Broken River System. This proposal was prepared in consultation with key stakeholders and partners and was approved by the CEO of the GB CMA.

You may notice that the format of this Seasonal Watering Proposal is different to previous years. The Victorian Environmental Water Holder (VEWH) has amended the Seasonal Watering Proposal guidelines in 2024-25 and reduced the length of the document whilst still retaining the key information including:

- what environmental watering actions may be delivered during 2024-25;
- the rationale for delivering these environmental watering actions;
- a summary of the engagement undertaken; and
- risk management.

2 SYSTEM OVERVIEW

Waterway manager – Goulburn Broken Catchment Management Authority

Storage manager – Goulburn-Murray Water

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

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

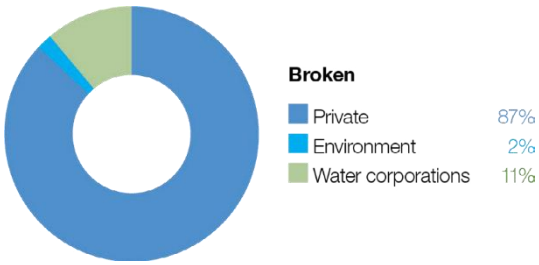


Figure 1: Water entitlements in the Broken system

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

The Broken River is a tributary of the Goulburn River, rising in the Wellington-Tolmie highlands and flowing northwest to Benalla and then west for a total distance of 190 km before it joins the Goulburn River near

Shepparton (Figure 2). Lake Nillahcootie is the main storage on the Broken River. It is about 36 km upstream of Benalla and harvests water from the river to support stock and domestic supply and irrigated agriculture. The main tributaries of the Broken River are Hollands Creek, Ryans Creek and Lima East Creek.

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

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

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

Upper Broken Creek has been regulated for more than a century. Before 2007, water was diverted into upper Broken Creek at Caseys Weir to meet local demand, but recent water savings projects have reduced the demand on the creek. There is now a low flow throughout the year between Caseys Weir and Waggarandall Weir. The flow below Waggarandall Weir is more variable and experiences regular cease to flow periods. These changes have reduced the amount of permanent aquatic habitat.

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

The bulk entitlement for the Broken system held by Goulburn-Murray Water stipulates that a minimum environmental flow – also known as passing flow – is to be maintained in the Broken River when there are natural flows into the system. The bulk entitlement also allows Goulburn-Murray Water and the Goulburn Broken CMA to agree to reduce the minimum passing flow and accumulate unused volumes for later releases that will provide a greater environmental benefit. Accumulated passing flow is the first volume lost when the storage spills. Environmental flows in upper Broken Creek are restricted by the volume of available supply, channel capacity and the need to avoid flooding low-lying, adjacent land.

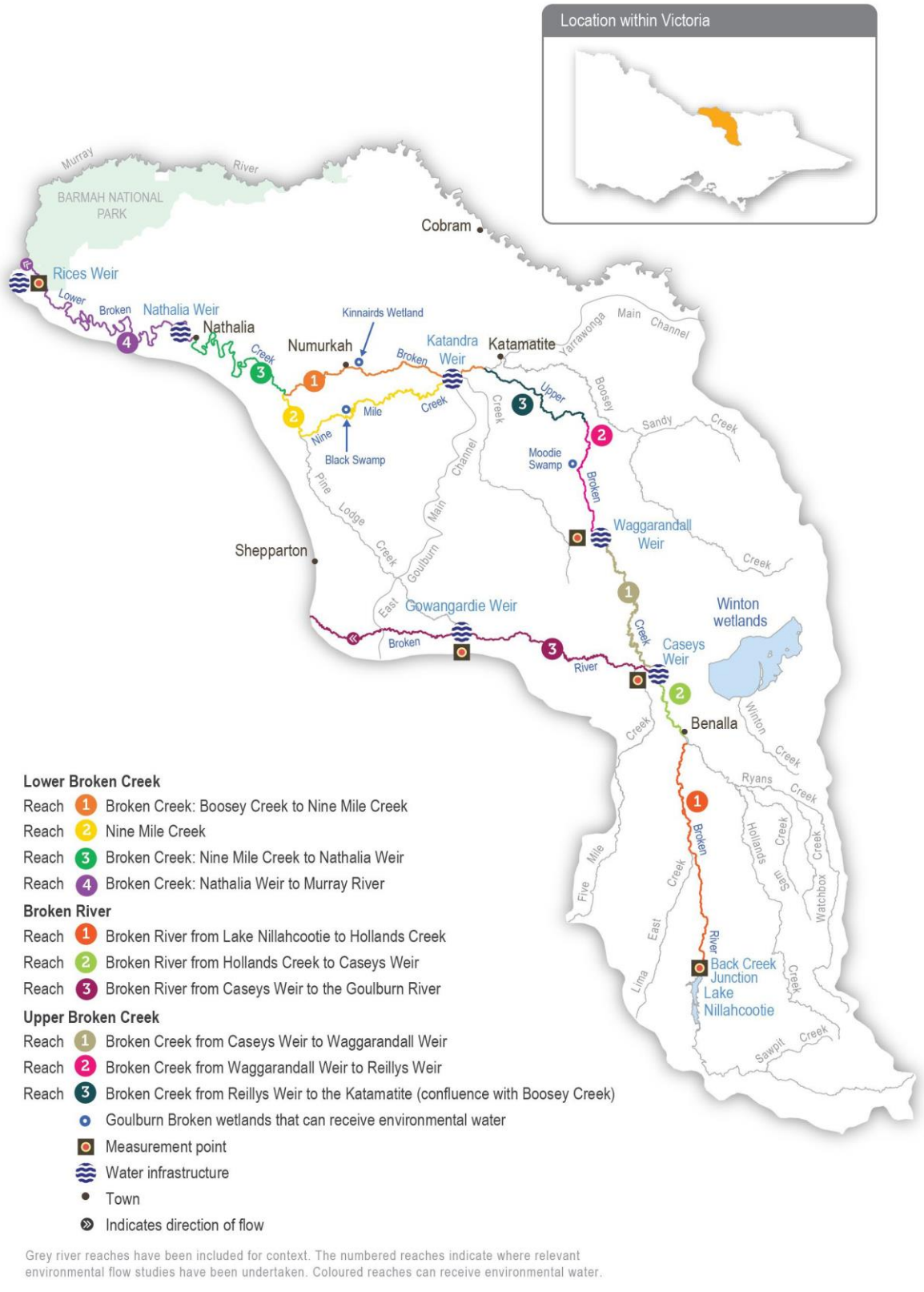


Figure 2: The Broken System

3 TRADITIONAL OWNER CULTURAL VALUES AND USES

The Broken River system flows through the lands of the Taungurung and the Yorta Yorta Peoples. The Broken Creek is on Yorta Yorta Country. Water for the environment in the Broken system supports the health of cultural values and landscapes, including intangible cultural heritage, valued species and traditional food and medicine plants.

Each year, the Goulburn Broken CMA meets with the Taungurung Land and Waters Council and the Yorta Yorta Nation Aboriginal Corporation to discuss plans for environmental watering in the Broken River and upper Broken Creek. The Taungurung Land and Waters Council and the Yorta Yorta Nation Aboriginal Corporation are also members of the Broken Environmental Water Advisory Group.

The Taungurung Land and Waters Council (TLaWC) plans to assess cultural values and objectives for the Broken River through healthy Country assessments like Aboriginal Waterway Assessments. These will help the Council develop more-specific cultural objectives for the Broken River system in future as well as culturally informed recommendations for water for the environment.

In 2021, the Yorta Yorta Nation Aboriginal Corporation provided the following statement about the cultural values of the Broken River system, including Broken Creek:

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

4 SOCIAL RECREATIONAL AND ECONOMIC VALUES AND USES

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

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

5 ENVIRONMENTAL VALUES AND OBJECTIVES

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

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

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

The environmental objectives for the management of the waterways key ecological values are summarised in Table 1 below.

Table 1: Broken River and upper Broken Creek environmental objectives

Environmental objectives in the Broken River and upper Broken Creek
F1 - Maintain native fish populations
G1 - Turn over bed sediments and scour around large wood to maintain in-channel habitat diversity
MI1 - Maintain waterbug diversity and abundance
PR1 - Maintain platypus populations
V1 - Maintain in-stream vegetation
WQ1 - Maintain water quality

6 ENGAGEMENT

Key community and stakeholder groups have been engaged during the development of this proposal. These include:

- The agencies directly involved in delivering the proposed priority flow recommendations including Goulburn-Murray Water (GMW), the VEWH and the CEWH.
- The agencies directly involved in the management of public land covered by the proposal (Parks Victoria).
- Traditional Owners (Yorta Yorta Nations Aboriginal Corporation and Taungurung Land & Waters Council) who have rights and interests in the land and water covered by the proposal. Yorta Yorta Nation Aboriginal Corporation is the Registered Aboriginal Party for the upper Broken Creek and the Broken River downstream of Benalla under the Aboriginal Heritage Act (2006). Taungurung Land and Waters Council is the Registered Aboriginal Party for the Broken River upstream of Benalla under the Aboriginal Heritage Act (2006).
- Individuals or groups potentially affected by or interested in environmental flows and or the health of the Broken River and upper Broken Creek. This includes water users along the waterways (GMW diversion license holders), fishers, local government and environment groups.

Ongoing engagement with these groups primarily occurs through three mechanisms – the Broken Environmental Water Advisory Group (EWAG), the Goulburn Broken Operational Advisory Group (GBOAG) and direct engagement via emails, telephone and face to face meetings.

GMW is the key water delivery agency. When the final proposal for 2024-2025 is agreed, communications with GMW are aimed at making clear what the intended environmental watering actions are and their intended purpose. Then, throughout the season, there will be regular communications (phone and email) directly with the water resource management group in GMW to understand unregulated flows, GMW planned consumptive use releases, and to organise environmental watering actions.

The VEWH will use this proposal as the basis (in whole or part), in developing their Seasonal Watering Plan. Water allocated is to be delivered in accordance with the plan and the plan is used to seek agreement from

other water holders for the use of their water. Routine communication (phone and email) will report on deployment of water under the plan as the year unfolds.

The CEWH also undertakes annual planning and publishes plans on the CEWH website. Planning by the GBCMA, CEWH and VEWH is undertaken in close cooperation with each other to create a shared understanding of the priority watering actions and the ecological outcomes to be achieved.

To assist with the environmental water management program, the GB CMA established the Broken Environmental Water Advisory Group to provide advice on environmental water planning (including seasonal watering proposals and water management plans) and on environmental health trends occurring in the rivers, creeks and wetlands. The focus of the group is the Broken River from Lake Nillahcootie to Shepparton, the Broken Creek from Caseys Weir to the Murray River and wetlands associated with these systems. The group was established in April 2012 and comprises community members, Traditional Owners (Taungurung Land & Waters Council and Yorta Yorta Nations Aboriginal Corporation) and representatives from key agency partners (VEWH, CEWH, PV and GMW).

Traditional Owners are also directly consulted during the development and implementation of the Broken River System seasonal watering proposal through regular meetings with GB CMA staff.

The general public and individuals or groups potentially affected by or interested in environmental flows and or the health of the Broken River and upper Broken Creek are primarily engaged through media releases and partner communication platforms. The communication objective for this audience is to provide information about decisions to deliver environmental water and the expected ecological outcomes. A secondary objective is to build public understanding of the change from past flow regimes to a future one managed to achieve improved river health.

Table 2 outlines the communication process the GB CMA has undertaken during the development of this seasonal watering proposal.

Table 1: Summary of stakeholder engagement that informed this Seasonal Watering Proposal

Stakeholder(s)	Engagement method	Engagement purpose
Government agencies • GMW • VEWH • CEWH • Parks Victoria	• Broken EWAG meeting 19 March 2024 • Direct engagement • Review of draft proposal	• Seek input to development of the proposal. Understand any delivery constraints or issues and plan for environmental water delivery in 2024-25. • Gather observations on waterway health and trends.
Traditional Owners • Yorta Yorta Nation Aboriginal Corporation • Taungurung Land and Waters Council	• Broken EWAG meeting 19 March 2024 (couldn't attend but received meting notes) • Direct engagement • Review of draft proposal	• Seek feedback on environmental water priorities for 2024-25. • Identify cultural objectives for the waterways and incorporate them into environmental water planning. • Gather observations on waterway health and trends.
Recreational Users • EWAG members	• Broken EWAG meeting 19 March 2024	• Seek feedback on environmental water priorities for 2024-25. • Gather observations on waterway health and trends. • Confirm recreational and social uses of the waterways.
Environment Groups • Goulburn Valley Environment Group	• Broken EWAG meeting 19 March 2024 (couldn't attend but received meting notes)	• Seek feedback on environmental water priorities for 2024-25. • Gather observations on waterway health and trends. • Confirm recreational and social uses of the waterways.
Landholders • EWAG members	• Broken EWAG meeting 19 March 2024	• Seek feedback on environmental water priorities for 2024-25. • Gather observations on waterway health and trends. • Confirm recreational and social uses of the waterways.

7 SCOPE OF ENVIRONMENTAL WATERING

This section describes the range of potential priority watering actions which may be delivered during 2024-25 including their volume, timing, duration and frequency.

7.1 Broken River objectives and recommendations

An environmental flows study for the Broken River was completed in 2001 (Cottingham et al 2001) and updated in the Environmental Watering Plan completed in 2013 (Cottingham et al 2013b). The Environmental Watering Plan developed objectives and flow recommendations (watering actions) for the management of the Broken River's key ecological values. To facilitate this the Broken River was divided into the following three reaches:

1. Broken River from Lake Nillahcootie to Holland's Creek (38 km);
2. Broken River from Holland's Creek to Caseys Weir (14 km); and
3. Broken River from Caseys Weir to the Goulburn River (69 km).

Given the small volume or environmental water available and the opportunity to utilise Inter-valley water transfers between December and March, the focus of this proposal is on maintaining minimum base or low flows and increasing flow variability in all reaches. The relevant objectives, flow recommendations (watering actions) and ecological values are listed in **Error! Reference source not found.**. The complete list of objectives and flow recommendations (watering actions) for the management of the Broken River's key ecological values are outlined in Appendix 1. Broken River watering actions can contribute to flows in the lower Goulburn River.

The key environmental flow compliance points for the Broken River are:

- Back Creek Junction in reach 1;
- Caseys Weir in reach 2; and

- Gowangardie Weir in reach 3.

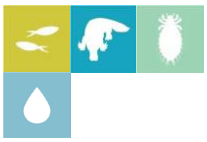
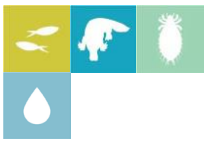
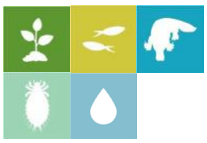
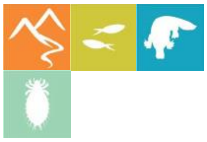
7.2 Upper Broken Creek objectives and recommendations

An environmental flows study for the Broken Creek was completed in 2007 (SKM 2007) during the construction of the Tungamah Pipeline Scheme. Once completed the scheme was expected to lead to a more intermittent flow regime in the upper Broken Creek. However, ongoing irrigation diversions along the upper Broken Creek to supply irrigators between Caseys Weir and Waggarandall Weir means a more perennial flow regime persists. This permanent flow means that some sections of the upper Broken Creek can support environmental values that were not considered in the 2007 study and some of the environmental flow objectives and flow recommendations (watering actions) established in the 2007 study are no longer valid. Consequently, a new flow study was completed in 2017 that developed objectives and flow recommendations (watering actions) that better reflected the ecological values and flow regime of the upper Broken Creek. To facilitate this the upper Broken Creek was divided into the following three reaches (the same reaches identified in the 2007 study):

1. Caseys Weir to Waggarandall Weir (40 km);
2. Waggarandall Weir to Reillys Weir (24 km); and
3. Reillys Weir to Katamatite (25 km).

Given the delivery constraints in reach 2 and the small volume of environmental water available, the focus of this proposal is on maintaining minimum base or low flows in reach 1. The relevant objectives, flow recommendations (watering actions) and ecological values are listed in **Error! Reference source not found.**. The complete list of objectives and flow recommendations (watering actions) for the management of the upper Broken Creek's key ecological values are outlined in Appendix 2. Upper Broken Creek watering actions can contribute to flows in the lower Broken Creek. The key environmental flow compliance points for the upper Broken Creek are Waggrandall Weir for low flows and Caseys Weir for freshes.

Table 3: Potential Watering Actions in 2024-25

Potential environmental watering action	Expected watering effects	Environmental objectives
Upper Broken Creek[1] - reach 1 (compliance points - Waggarandall Weir and Caseys Weir)		
Year-round low flow (5-10 ML/ day)	• Maintain aquatic habitat and connections between weir pools for native fish and platypus. • Inundate benthic surfaces and large wood located at the bottom of the channel, which serves as habitat for waterbugs. • Maintain water quality and dissolved oxygen levels for native fish, platypus and waterbugs.	
Winter/spring fresh (50 ML/ day for 10 days from July to November)[2]	• Increase food resources for native fish, platypus and waterbugs. • Increase flow and flush pools to improve water quality and dissolved oxygen levels. • Increase longitudinal connection that provides opportunities for downstream dispersal of juvenile platypus in early winter • Provide migration cues and longitudinal passage for native fish	
Year round fresh (trigger-based, of 20-50 ML/day for ten days)[2] Triggers - low dissolved oxygen/low or cease-to-flow conditions/high water temperatures	• Increase flow and flush pools to improve water quality and dissolved oxygen levels.	
Broken River[3] – reaches 1, 2 and 3 (compliance points - Back Creek Junction/Caseys Weir/Gowangardie Weir)		
Year-round low flow (15-100 ML/day)	At 15 ML/day • Provide minimum longitudinal connection along the length of river and habitat for native fish, aquatic plants, platypus and waterbugs. • Maintain water quality and oxygen levels for native fish, platypus and waterbugs. At 30-100 ML/day • Increase habitat for in-stream and fringing vegetation, and prevent terrestrial vegetation from colonising the stream bed. • Enhance riffles, pools and slackwater to provide diverse hydraulic habitat for native fish, aquatic plants, platypus and waterbugs. • Improve water quality and oxygen levels for native fish, platypus and waterbugs.	
Summer/autumn fresh (one fresh of 400-500 ML/day for two to five days during December to May)	• Scour sediments around large wood, turn over bed sediments, replenish biofilms and maintain macrophyte habitat. • Provide flow cues to stimulate native fish to breed and migrate. • Increase food resources for native fish, platypus and waterbugs.	

1. Potential watering actions in upper Broken Creek will be delivered at a lower magnitude if insufficient water is available to achieve the target

magnitude.

2. Compliance point is Caseys Wier. The maximum volume that can be diverted from Caseys Weir to the Broken Creek is 50 ML/day,
3. 30-100 ML/day is the recommended flow required to ensure optimal habitat and water quality is achieved in the Broken River. When water availability is low, a flow may need to be delivered at 15 ML per day to provide the minimum habitat and water-quality requirements to sustain populations of fish, platypus and vegetation while conserving enough water to deliver throughout the year.

8 SCENARIO PLANNING

8.1 Climate Outlook for 2024-2025

According to the latest weather outlook information from the Bureau of Meteorology, March to June 2024 maybe dryer and warmer than average in the Goulburn and Broken Catchments. Lake Nillahcootie is currently 92% full and water is continuing to be released to meet irrigations demands. At the same time last year Lake Nillahcootie was only 91% full.

The current (February 2024) Broken system outlook for seasonal determinations indicate:

- an opening high security water share seasonal determination of 38 % in a wet Climate scenario, 11% in an average scenario and 0% in dry and extreme dry scenarios;
- a high security water share seasonal determination of 100% by October 2023 in wet and average Climate scenarios and 29% in a dry Climate scenario; and
- a high security water share seasonal determination of 3% in an extreme dry Climate scenario.

This allocation outlook is similar to last year's and is outlined in more detail in Table 4 below.

Table 4: Broken system outlook for seasonal determination of high reliability shares

Climate Scenario	1 July 2024	15 August 2024	17 October 2024	15 February 2025
Wet	38%	43%	100%	100%
Average	11%	43%	100%	100%
Dry	0%	2%	29%	49%
Extreme Dry	0%	0%	0%	3%

Source: Current Outlook - Northern Victoria Resource Manager (nvrm.net.au)

Under extreme dry and dry climate scenarios, the volume of environmental water available is potentially much less than the volume required to deliver the desired priority watering actions. However, opportunities to use inter-valley water transfers in the Broken River to meet priority watering actions will be considered and environmental water holders can back trade water to provide additional water for environmental flows in the Broken River and upper Broken Creek.

8.2 Scenario Planning

The Broken River system has a highly variable flow, depending on catchment runoff and the operation of the water supply delivery system. Environmental flow management aims to allow catchment runoff and operational releases to meet as many priority watering actions as possible, and then deploy water from environmental entitlements into the highest priority gaps that remain. However, under different possible climate scenarios (from dry to wet), the environmental flow gaps move dramatically and the deployment of environmental water changes. Therefore, plans are prepared for a range of possible climate scenarios to understand how the priorities and required volumes for deployment of environmental water change.

The scenarios are based on current conditions such as the volumes of water in storage and they assume the availability of all environmental water entitlements and their associated water allocations in the Broken River system. The scenarios then determine how best to maximise the environmental outcomes from their use.

In most cases, the volumes available are much smaller than the desirable priority watering actions and more water could be used if available.

Importantly, the planning is not concerned with the probability of any particular climate scenario (or in picking the most likely scenario) it merely ensures there is a plan if any scenario does occur. While various climate

scenario indicators exist, predicting the conditions for the coming season (both winter/spring and summer/autumn) is not reliable.

The scenarios have been picked to highlight the key decisions that will need to be made about environmental water deployment for 2024-2025. The scenarios range from the driest conditions to the wettest. Importantly, the actual management of water through the season must be adaptive, with water deployment decisions adjusting as the season unfolds, particularly in response to timing issues within the season. **Error! Reference source not found.**5 outlines the range of scenarios for water use in the Broken River system in 2024-2025.

Summer storms in 2010-2011, 2011-2012, 2016-17, 2021-2022 and 2023-2024 produced significant runoff in the Broken River catchment. These events are erratic in nature, and not correlated with the climate scenarios above (which are based on winter/spring rainfall). The scenarios assume these events do not occur. If one or more events do occur, they will potentially reduce the need for environmental water to be delivered down the upper Broken Creek and Broken River in summer/autumn. The VEWH and or CEWH can also back trade water into the system (if available) to help meet a shortfall if required.

8.2.1 Triggers for action

This GB CMA proposal is based on using the seasonal allocation of all environmental entitlements expected to be available in the Broken River system in 2024-2025. Trade opportunities and the use of banked water to meet priority watering actions have not been considered due to the uncertainty around their availability.

8.2.1.1 Upper Broken Creek

The highest priority is to maintain spring and summer minimum low flows in the upper Broken Creek (in all climate scenarios). Spring and summer are the most important periods for instream production and native fish, macroinvertebrate and platypus movement and reproduction. Summer low flows also help to maintain water quality, which is often at greatest risk at this time of the year due to high ambient temperatures. There will only be sufficient environmental water and back trade opportunities to fully meet this requirement under wet and average climate scenarios. There may be sufficient environmental water in the dry climate scenario to deliver a reduced spring and summer base flow.

The next priority is to maintain the autumn low flow in the upper Broken Creek (in all climate scenarios) followed by maintaining the winter minimum low flow in the upper Broken Creek (in all climate scenarios). Autumn is an important time for dispersal of juvenile platypus and is relatively important for instream production. There may be sufficient environmental water and back trade opportunities to meet autumn and winter minimum low flows under average and wet climate scenarios.

The third priority is to maintain water quality in the upper Broken Creek to support native fish, platypus and macroinvertebrates under all climate scenarios. This involves delivering water in response to extreme weather or flows that may cause poor water quality (e.g., floods, low and cease to flow events, intense rainfall and fire). Flow, weather and dissolved oxygen levels will be monitored to inform the timing and need for this action. Under the extreme dry and dry climate scenarios there will be insufficient environmental water and back trade opportunities to meet the water requirements. However, if the other priority watering actions are not triggered environmental water and back trade could be used to deliver a modified version of this watering action.

The final priority is to deliver a winter or spring fresh in average and wet climate scenarios (this priority watering action may be met by unregulated flows in a wet climate scenario). Under the extreme dry and dry climate scenario there will be insufficient environmental water and back trade opportunities to meet the water requirements. However, if the other priority watering actions are not triggered environmental water and back trade could be used to deliver a modified fresh. The fresh could also be delivered in coordination with environmental water deliveries to Moodie Swamp to maximise the use of available environmental water.

8.2.1.2 Broken River

The highest priority is to maintain spring and summer low flows in all reaches of the Broken River (in all climate scenarios). Spring and summer are the most important periods for instream production and native fish,

macroinvertebrate and platypus movement and reproduction. Summer low flows also help to maintain water quality, which is often at greatest risk at this time of the year due to high ambient temperatures.

The next priority is to maintain the autumn low flow in all reaches of the Broken River (in all climate scenarios) followed by maintaining the winter low flow in in all reaches (in all climate scenarios). Autumn is an important time for dispersal of juvenile platypus and is relatively important for instream production.

There may not be sufficient environmental water and back trade opportunities to meet these priority watering actions under extreme dry and dry climate scenarios. Under average and wet climate scenarios operational releases and unregulated flows are expected to meet the low flow requirements.

The final priority is to deliver a summer or autumn fresh in reach 1 of the Broken River in average and wet climate scenarios (this priority watering action may be met by unregulated flows in a wet climate scenario). Under the dry climate scenario there will be insufficient environmental water and back trade opportunities to meet the water requirements. However, if the other priority watering actions are not triggered environmental water and back trade could be used to deliver a modified fresh.

Flow, the trade water balance, seasonal determinations and the weather will be monitored by the GB CMA throughout the year to inform the timing and need for upper Broken Creek and Broken River priority watering actions. Where priory watering actions in the upper Broken Creek and Broken River are competing for water, they may be modified to meet the available water resources or prioritised in consultation with technical experts based on risk. The above information is summarised in Table 5. Additional information on priority watering actions is provided in Appendix 3.

Table 5: Scenario Planning in 2024-25

Planning scenario	Extreme Dry	Dry	Average	Wet
Expected conditions	• Limited or no unregulated flow in Broken River or upper Broken Creek • Low releases of operational water in Broken River • Likely low and cease-to-flow events throughout the year in all reaches	• Low, unregulated flow in Broken River. Low or no unregulated flow in upper Broken Creek • Low releases of operational water in Broken River and upper Broken Creek • Possible low and cease-to-flow events throughout the year in all reaches	• High winter/spring flow in Broken River • Increased releases of operational water in Broken River • Periods of unregulated flow in upper Broken Creek	• High winter/spring flow in Broken River • Increased releases of operational water in Broken River • Periods of unregulated flow in upper Broken Creek with some winter/spring freshes
Expected availability of water for the environment	• 3% high reliability water supply allocations by February • Irrigation season may be shortened • Carry over available at the start of the season • 187 ML[1]	• 49% high reliability water supply allocations by February • Irrigation season may be shortened • Carry over available at the start of the season • 306 ML[1]	• 100% high reliability water supply allocations by October and 100% low reliability water supply allocations by December • Carry over available at the start of the season • 647 ML[2]	• 100% high reliability water supply allocations by October and 100% low reliability water supply allocations by December • Carry over available at the start of the season • 647 ML[2]
Upper Broken Creek - reach 1				
Potential environmental watering – tier 1 (high priorities)	Tier 1a (can be achieved with predicted supply)			
	• Year-round low flow 5-10 ML/day (partially delivered)	• Year-round low flow at 5-10 ML/day (partially delivered)	• Year-round low flow at 5-10 ML/day (partially delivered)	• Year-round low flow at 5-10 ML/day (partially delivered)

Planning scenario	Extreme Dry	Dry	Average	Wet
	Tier 1b (supply deficit)			
	• Year-round low flow 5-10 ML/day (remaining volume) • Year-round fresh at 50 ML/day[3] (trigger based) for 10 days	• Year-round low flow 5-10 ML/day (remaining volume) • Year-round fresh at 50 ML/day[3] (trigger based) for 10 days	• Year-round low flow 5-10 ML/day (remaining volume) • Year-round fresh at 50 ML/day[3] (trigger based) for 10 days • Winter/spring fresh at 50 ML/day for 10 days	• Year-round low flow 5-10 ML/day (remaining volume) • Year-round fresh at 50 ML/day[3] (trigger based) for 10 days • Winter/spring fresh at 50 ML/day for 10 days
Potential environmental watering – tier 2 (additional priorities)	• NA	• NA	• NA	• NA
Broken River – all reaches				
Potential environmental watering – tier 1 (high priorities)	Tier 1a (can be achieved with predicted supply)			
	• NA	• NA	• Year-round low flow at 30-100 ML/day	• Year-round low flow at 30-100 ML/day
	Tier 1b (supply deficit)			
	• Year-round low flow at 15-30 ML/day	• Year-round low flow at 15-30 ML/day	• Broken River summer or autumn fresh at 400-500 ML/day for 2 days	• Broken River summer or autumn fresh at 400-500 ML/day for 2 days
Potential environmental watering – tier 2 (additional priorities)	• NA	• NA	• NA	• NA
Possible volume of water for the environment required to achieve objectives	• 187 ML (Tier 1a) • 3888 – 5988 (Tier 1b) • NA (Tier 2)	• 306 ML (Tier 1a) • 3769-5869 (Tier 1b) • NA (Tier 2)	• 647 ML (Tier 1a) • 3900-7254 (Tier 1b) • NA (Tier 2)	• 647 ML (Tier 1a) • 3900-7254 (Tier 1b) • NA (Tier 2)
Priority carryover requirements for 2025-26	• N/A			

1. Maximum carry over in the Broken System is 50% of the high reliability water share entitlement volume.
2. High reliability allocation and carry over cannot exceed the high reliability water share entitlement volume.
3. Assumes only one delivery event.

9 RISK MANAGEMENT

The risks associated with the delivery of the priority watering actions, the identified mitigation actions and the lead agency responsible for implementing the mitigation actions are listed in Table 6.

Table 6: Risk assessment of proposed water delivery

Legend for Tables:

1. Risk category abbreviations are: Env. – environment/sustainability; BC – business cost; Safety – People/safety/wellbeing; Rep – Political/reputation; Legal – legal consequence; Service – service delivery
2. L refers to the Likelihood of a risk occurring. Abbreviations for consequence ratings are: AC – almost certain; L – likely; P – possible; U – unlikely; R - rare
3. C refers to the Consequence if the risk occurs. Abbreviations for consequence ratings are: N – negligible; Min – minor; Mod – moderate; Maj – major; Ext - extreme

No.	Risk category[1]	Risk description	L[2]	C[3]	Risk rating	Mitigation actions	Lead for action	Residual Risk
1	Env	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.	P	Maj	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	Low
2	Rep	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.	P	Maj	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 CMA CMA	Low

No.	Risk category[1]	Risk description	L[2]	C[3]	Risk rating	Mitigation actions	Lead for action	Residual Risk
3	Env	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.*	P	Min	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	Low
4	Env	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. Has occurred in the upper Broken Creek below Caseys Weir offtake due to instream vegetation, which is also limiting flow capacity.	P	Mod	Medium	Review accounting and measurement processes to be used to ensure that techniques are agreed, and monitoring/measurement sites are operational. GMW to undertake additional gauging readings. Instream vegetation control in Broken Creek programmed for autumn (weather conditions permitting).	GMW GMW GMW CMA	Low
5	BC	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.*	U	Maj	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	Low
6	Env	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.	U	Maj	Low	Monitor ABA balances and undertake regular communications with CMA and RWC as part of portfolio management activities.	VEWH CMA	Low

No.	Risk category[1]	Risk description	L[2]	C[3]	Risk rating	Mitigation actions	Lead for action	Residual Risk
		Notes: Planning watering actions also includes decisions around the carryover and trade of water as alternatives to current year water use decisions.				Ensure that deliveries are reported progressively throughout the event and are monitored against ordered volume.	GMW	
7	Env	Planned maintenance of water delivery infrastructure results in planned/specified flows not being achieved, leading to a failure to achieve planned environmental outcomes.	L	Min	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	Low
8	Env	Failure of poorly maintained or vandalised delivery infrastructure results in planned/specified flows not being achieved, reducing the ability to achieve planned environmental outcomes (including failure or damage due to vandalism).	L	Mod	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.* For privately owned assets, arrange approvals to use/operate assets and undertake pre-delivery inspections. Report vandalism to police and review asset design to minimise opportunities for interference or damage. Communicate failures to the CMA. Initiate documentation of asset ownership and management arrangements in national parks. Consider monitoring options to detect vandalism, interference or failure of assets at individual sites with elevated risk.	Asset owner CMA Asset owner Asset owner PV Asset owner	Low
9	Env	Poor condition of delivery infrastructure results in the asset owner being unable to operate the	U	Mod	Low	Asset owner to undertake regular maintenance and pre-event asset inspections on delivery infrastructure.	Asset owner	Low

No.	Risk category[1]	Risk description	L[2]	C[3]	Risk rating	Mitigation actions	Lead for action	Residual Risk
		structure due to OH&S risks, leading to failure to deliver environmental flows and to achieve environmental objectives.				**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.	Asset owner CMA	
10	Env	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	L	Min	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 GMW GMW MDBA VEWH CMA VEWH	Low
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.	P	Maj	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.	CMA CMA GMW MDBA GMW MDBA	Low

No.	Risk category[1]	Risk description	L[2]	C[3]	Risk rating	Mitigation actions	Lead for action	Residual Risk
						Monitor deliveries to new locations to build an understanding of flow patterns and inundation thresholds and adjust releases accordingly. Seek advice from storage operator of any known changes in bank levels and commence to flow levels following flood events.	CMA GMW	
13	Rep	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.).	U	Mod	Low	Watering proposals to identify potential impacts. Communication of planned events, access closures, alternative recreational opportunities and alternative access routes. Plan event timings to limit flow changes during peak visitation periods.	CMA Land mgr CMA	Low
14	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).	U	Mod	Low	Communication and advice to commercial operators to alert them of environmental watering, via Land Manager as licensing authority.	Land mgr	Low
15	Serv Del	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)	U	Mod	Low	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	Low
16	Env	Environmental water deliveries result in low dissolved oxygen (DO) levels, with adverse environmental impacts.	U	Mod	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	CMA CMA CMA	Low

No.	Risk category[1]	Risk description	L[2]	C[3]	Risk rating	Mitigation actions	Lead for action	Residual Risk
17	Rep	Environmental water deliveries result in low DO levels, with adverse environmental impacts.	U	Maj	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. Communicate the mitigation actions/plans put in place to reduce risk of creating low DO events due to environmental water deliveries.	VEWH CMA CMA	Low
18	Env	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	P	Mod	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. Parks Victoria's BGA risk management plan for Northern Victoria Region that considers the potential risk of environmental water events is currently awaiting final approval. This plan outlines proactive and reactive monitoring and management responsibilities that Parks Victoria commits to as a Local Waterway Manager for BGA. Adequate BGA resourcing is considered as part of this plan. Regional monitoring and advice on BGA status.	CMA GMW Land mgr GMW GMW	Low
19	Rep	Environmental water management activities may conflict with or not complement water based recreational objectives, leading to loss of community support for activities.	U	Mod	Low	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.	VEWH CMA	Low

No.	Risk category[1]	Risk description	L[2]	C[3]	Risk rating	Mitigation actions	Lead for action	Residual Risk
						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). Implement earlier planning of events to provide more time for partners to consider and flag any potential issues for include in event plans.	CMA Land mgr. VEWH CMA	
20	BC	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.	P	Maj	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	Low
21	Env	Insufficient information and knowledge available to inform environmental water deliveries	U	Mod	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 CMA CMA	Low
22	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.	P	Mod	Medium	Undertake desktop reviews and site assessments with archaeologists, traditional owners and land managers, to identify approval needs and contingency measures.	CMA	Low

No.	Risk category[1]	Risk description	L[2]	C[3]	Risk rating	Mitigation actions	Lead for action	Residual Risk
						Obtain any necessary formal approvals/permits and implement required actions. Seek necessary resources to undertake approvals and assessments	CMA CMA	
23	Legal	Environmental watering causes harm to identified cultural heritage	U	Mod	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. Consider pre-watering site assessments or surveys with TO groups.	CMA DEECA VEWH CMA CMA	Low
24	Rep	Inability to demonstrate outcomes achieved through environmental watering activities may lead to a loss of public/political support for activities	P	Maj	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 high after mitigation actions.	DEECA VEWH CMA	Low
25	Env	Environmental deliveries improve conditions for non-native species (e.g., carp, invasive species, feral horses) leading to adverse environmental impacts. Or pest plants and animals prevent environmental water outcomes being achieved.	L	Mod	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, waterlily spraying program, feral animal programs).	DEECA CMA Land mgr	Medium

No.	Risk category[1]	Risk description	L[2]	C[3]	Risk rating	Mitigation actions	Lead for action	Residual Risk
						Implement pest reduction efforts prior to delivery of water, to ensure increases in populations remain within "tolerable" levels.	CMA Land mgr	
27	Env	Ineffective planning and/or uncoordinated water ordering results in administrative obstacles that prevent watering opportunities.	U	Mod	Low	Enable the full range of watering actions possible in seasonal watering proposals and the seasonal watering plan (as per SWP guidelines)	CMA VEWH	Low
29	Rep	River operators release water for flood mitigation which causes downstream flooding and public perceive the releases are for environmental purposes.	U	Mod	Low	River operators to clearly communicate to customers and the broader community when large releases are for operational purposes	GMW	Low
30	Rep	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.	P	Mod	Medium	Communications to inform the community on the drivers/reasons for high flows in river systems, especially under dry scenarios	GMW CMA	Low
31	Rep	Community concern over environmental releases under dry seasonal conditions may lead to a loss of support for environmental watering actions.	U	Mod	Low	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	Low
32	Rep	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.	P	Mod	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 has been heightened as a result of the 2018/19 Menindee fish death events.	CMA	Low
33	Env	Limited environmental deliveries may reduce opportunities to test ecological responses to environmental flows, impacting on effectiveness of research projects.	U	Mod	Low	Review monitoring program and adjust if possible. Reprioritise future flow targets.	CMA	Low

No.	Risk category[1]	Risk description	L[2]	C[3]	Risk rating	Mitigation actions	Lead for action	Residual Risk
34	Safety	Environmental releases create rapid or unexpected changes in flow conditions, resulting in injury to river users	U	Mod	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	Low

10 APPROVAL, ENDORSEMENT AND CONSENT

WATERWAY MANAGER APPROVAL OF THE SEASONAL WATERING PROPOSAL
I, the authorised representative of the agency shown below, approve the Seasonal Watering Proposal for the Broken River and upper Broken Creek system in 2024-25. SIGNED FOR AND ON BEHALF OF GOULBURN BROKEN CATCHMENT MANAGEMENT AUTHORITY Signature of authorised representative:    Name of authorised representative: Chris Cumming Position of authorised representative: Chief Executive Officer Date: 19/04/2024

ENDORSEMENT OF THE SEASONAL WATERING PROPOSAL

I, the authorised representative of the agency shown below, approve the Seasonal Watering Proposal for the Broken River and upper Broken Creek system in 2024-25.

Role	Endorsing partner	Representative Role	Status Date	Notes/Comments
Water Corporation	Goulburn-Murray Water	Andrew Shields River Operations Manager	☒ Endorsed. Date: 08/04/2024	*NA*
Land Manager	Parks Victoria	Kane Weeks Regional Director – Northern Victoria	☒ Endorsed. Date: 17/04/2024	*NA*
Traditional Owner	Yorta Yorta Nation Aboriginal Corporation	Jay Whittaker Whole of Country Manager	☒ Endorsed. Date: 16/04/2024	*NA*
	Taungurung Land and Waters Council	Voytek Lapinski Water Program Manager	☒ Endorsed. Date: 19/04/2024	*NA*

CONSENT TO USE OF CONTENT

Role	Endorsing partner	Delegate Role	Content	For use in the		Notes
				Seasonal Watering Proposal	Seasonal Watering Plan	
Traditional Owner	Yorta Yorta Nation Aboriginal Corporation	Jay Whittaker Whole of Country Manager	Chapter 3	☒ Consent provided. Date:16/04/2024	☒ Consent provided. Date: 16/04/2024	*NA*
	Taungurung Land and Waters Council	Voytek Lapinski Water Program Manager	Chapter 3	☒ Consent provided. Date: 19/04/2024	☒ Consent provided. Date: 19/04/2024	*NA*

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12 APPENDICES

12.1 Appendix 1: Broken River ecological objectives and flow recommendations

The following table outlines the ecological objectives and associated flow components established for the Broken River in Cottingham et al (2013a). This table is be read in conjunction with the environmental flow recommendations outlined in the tables below this.

Ecosystem Attribute	Environmental or Ecological Values	Potential flow related threats	Flow-related ecological objectives	Reach	Flow Component	Mechanism	Season
Geomorphology	Geomorphic processes contribute to the availability and quality of in-channel and riparian habitat	• Reduced frequency of flow events capable of scouring sediments from pools • Reduced magnitude of spring and summer baseflow that allows encroachment by terrestrial vegetation • Longer than natural duration of low flow events, resulting in excessive deposition of fine materials. • Reduced frequency of flow events that maintain connectivity with riparian and floodplain habitats.	**G1**: Provide baseflow adequate to allow the persistence of aquatic macrophytes at the bank toe.	All	Base flow	Maintain wetted area to allow aquatic macrophytes to persist at the toe of the bank.	All
			G2: Provide baseflow to prevent terrestrial vegetation colonizing the stream bed.	All	Base flow	Maintain wetted area to halt the encroachment of terrestrial vegetation into the stream bed.	All
			G3: Maintain the rates of bed material movement to maintain bed diversity (sand and gravel bed).	All	Winter-spring freshes	Flows of sufficient magnitude to provide critical shear stress to periodically mobilize sand. Flows of sufficient magnitude to scour fine-grained (silt/clay) sediments from surficial coarse-grained sediments.	Win, Spr
			G4: Flows to turn over bed sediments in runs and scour around large wood.	All	Summer-autumn and winter-spring freshes	Flows of sufficient magnitude to provide critical shear stress to turnover bed sediments and scour around large wood.	All
			G5: Provide bench inundation to maintain bench form (and wet vegetation and promote the deposition/retention of organic matter).	All	Winter- spring freshes	Inundation of mid-level benches to a depth of >0.5 m above bench surface.	Win, Spr
			G6: Maintain connectivity between the channel, anabranches and wetlands.	All	Winter-spring bankfull and overbank flows	Flows of sufficient magnitude to inundate anabranches, wetlands and floodplain areas.	Win, Spr
	Intrinsic value of native vegetation	• Decreased	**R1**: Improve the longitudinal and lateral extent and condition of	All	Winter-spring freshes (Reach	Riparian vegetation (canopy layer as	Win, Spr

Ecosystem Attribute	Environmental or Ecological Values	Potential flow related threats	Flow-related ecological objectives	Reach	Flow Component	Mechanism	Season
Vegetation	Preservation of endangered EVCs Protection against bank/channel erosion and sediment suspension Interception of catchment-derived nutrients and sediments Provision of faunal habitat Moderation of in-stream temperatures	incidence of winter-spring flows, with impacts on freshes (especially in Reach 1) • Decreased incidence of bankfull and overbank flows (all Reaches) • Decrease in variability in flows (especially in Reach 3)	remnant native vegetation at the top of the bank and on the floodplain, with a focus on EVC 56: Floodplain Riparian Woodland.		1) (synonymous with bankfull flows in reaches 2 and 3) Winter-spring bankfull flows (Reaches 2 ad 3) Winter-spring overbank flows (Reaches 2 ad 3)	well as understorey) generally requires periodic inundation to maintain good condition of adults and to permit sexual recruitment of juveniles into the population.	
			W1: Maintain a mosaic of wetlands features, including maintenance of individual wetland/vegetation components within Floodplain Wetland Aggregate EVC.	All	Winter-spring freshes (based on wetland commence to fill data that only exists for Reach 3) Winter-spring bankfull flows	Wetland vegetation (generally requires alternating wet and dry cycles (involving periodic inundation and desiccation) to maintain a diversity of habitats and plant species, good condition of adults and to permit sexual recruitment of juveniles into the population.	Win, Spr
			W2: Maintain lateral linkages (hydrological and biological) between floodplain wetlands and main-stream channel of river.	All	Winter-spring overbank flows (to inundate floodplain more generally)	Floodplain rivers and their floodplains require lateral continuity to permit movement of adults and propagules among in-channel habitats, riparian habitats and floodplain wetlands for full ecological functioning.	Win, Spr

Ecosystem Attribute	Environmental or Ecological Values	Potential flow related threats	Flow-related ecological objectives	Reach	Flow Component	Mechanism	Season
					Winter-spring bankfull flows (all reaches)		
			IC5: Maintain in-channel native submerged and emergent vegetation.	2 and 3	Base flow (all year) Summer-autumn and winter-spring freshes	All-year base flows create conditions of permanent inundation that allow obligate submerged native plant taxa to establish and preclude invasion by flood-intolerant taxa. Freshes required to scour attached periphyton from plant surfaces. Freshes also provide a mosaic of habitats suitable for colonisation by different types of emergent water-dependent vegetation.	All
			IC6: Inundate benches, bars and low levels of the river bank to entrain organic matter and drive ecological processes such as carbon and nutrient cycling	All	Winter-spring freshes	Freshes required to entrain organic matter and from benches.	Win, Spr
Invertebrates	Invertebrates contribute to aquatic biodiversity, are important measures of river health and are integral components of food webs	• Reduced frequency of flow events capable of scouring sediments from pools • Reduced magnitude of	MI1: Maintain areas of riffles and runs.	1	Base flow (all year)	Flows of sufficient magnitude to inundate riffles and maintain runs.	All
			MI2: Maintain hydraulic habitat diversity to ensure that there is sufficient water to provide flowing and slackwater habitats within the channel	All	Spring-autumn baseflow	Flows of sufficient magnitude to maintain hydraulic habitat diversity, including slackwater.	Spr, Sum, Aut

Ecosystem Attribute	Environmental or Ecological Values	Potential flow related threats	Flow-related ecological objectives	Reach	Flow Component	Mechanism	Season
		spring and summer base flows that allows encroachment by terrestrial vegetation • Longer than natural duration of low flow events, resulting in excessive deposition of fine materials. • Reduced frequency of flow events that maintain connectivity with riparian and floodplain habitats.	**MI3**: Maintain habitat for macrophytes that provide crucial habitat for macroinvertebrates	All	Baseflow (all year) Summer-autumn and winter-spring freshes	As for IC4 and IC5.	Spr, Sum, Aut
			MI4: Scour fine sediment from the surface of the substrate to promote biofilm productivity	All	Winter-spring baseflow Winter-spring freshes	As for IC1 and IC4.	Win, Spr
			MI5: Provide floodplain connection for exchange of organic matter and fine sediment.	All	Winter-spring bankfull (connects to low level wetlands and other features) Winter-spring overbank flows (widespread floodplain connection)	As for R1	Win, Spr,
			MI6: Retain natural seasonality to ensure synchronicity of life cycle stages with appropriate flows.	All	Spring-autumn baseflow Winter-spring freshes Winter-spring bankfull flows Winter-spring overbank flows	Covered by all previous objectives.	All
Native fish	Native fish contribute to aquatic biodiversity, are key predator in aquatic food webs, valued for recreational fishing. In particular, Murray cod, Macquarie perch and	• Reduced magnitude of base flows that limit the area of habitat available for native	**NF1**: Provide low flows that maintain adequate habitat for native fish populations, particularly slack-water habitats and deep pools	All	Baseflow	Flow of sufficient magnitude to maintain low-flow (e.g. slackwater) habitat and pools.	Sum, Aut
			NF2: Provide flows sufficient to allow fish passage	All	Baseflow	Flow of sufficient depth across the	All

Ecosystem Attribute	Environmental or Ecological Values	Potential flow related threats	Flow-related ecological objectives	Reach	Flow Component	Mechanism	Season
	Silver perch are listed as vulnerable or threatened and are the focus of management objectives in the Goulburn-Broken Regional River Health Strategy.	fish. • Reduced magnitude of base flows that limits fish passage along river reaches. • Reduced frequency of spring flow pulses that serve as migration cues for some native fish. • Reduced frequency and magnitude of floodplain/wetland inundation events that provide habitat for some fish species, enhance riverine production and deliver food material back to the river.			Summer-autumn freshes	channel to allow fish passage.	
			NF3: Provide to water access to billabongs and flood-runners to provide additional habitat diversity and food sources that contribute to production.	All	Winter-spring bankfull flows	Flow of sufficient magnitude to inundate flood runners and floodplain wetlands.	Win, Spr
			NF4: Provide flow cues to stimulate movements	All	Variability	Flow events of sufficient magnitude to serve as breeding and migration cues.	All

Environmental flow recommendations for reach 1 outlined in Cottingham et al (2013a)

Objectives (habitat feature in parenthesis)	Main Flow Components	Flow Recommendation	Rationale
Recommendations for Low flow			
MI1, IC1 (riffles)	• Summer-autumn low flow	Minimum flow of 30 ML/d, or natural	• From HECRAS: water to cover riffles require >30 ML/d.
MI2 (slackwater)	• Spring-autumn low flow	Minimum flow of 30-100 ML/d, or natural (see accompanying rationale for expanded explanation) Absolute minimum of 10 ML/d (the desire is for this flow to persist along the length of the river)	• Meeting the needs of Reach 3 is assumed to meet the needs of Reach 1. See low flow objective MI2 for Reach 3 for full rationale.
IC2 (cobble and gravel bars)	• Winter-spring low flow	200 ML/d or natural	• Maintain minimum water level in stream at 10 cm over cobble and gravel bars. From HECRAS: ○ Winter-spring low flow requires >200 ML/d or natural.
NF1 (slackwater and pools)	• Summer-autumn low flow	As for MI2	• As for MI2.
MI3, MI6	• Low flow (all year)	As for MI1 and MI2.	• As for MI1 and MI2.

Objectives (habitat feature in parenthesis)	Main Flow Components	Flow Recommendation	Rationale
(vegetation habitat and synchronicity)			
IC5 (vegetation habitat)	• Low flow (all year) • Summer and winter freshes	NA	• Reach 1 – minimal submerged vegetation – no specific recommendation for Reach 1. • Vegetation needs covered by recommendations for Reaches 2 and 3.
Recommendations for Freshes			
IC3 (vegetation encroachment on sand bars)	• Winter-spring freshes	270 ML/d. Frequency is 2 per year in dry years and 4 per year in average and wet years. Duration is 3 days in dry years, 6 days in average years and 9 days in wet years.	• Winter freshes to inundate low-lying sand bars. Based on HECRAS: ○ Reach 1 requires >270 ML/d,
G4 (scour around large wood)	• Summer-autumn and winter-spring freshes	400 ML/d. Frequency is 3 per year (all years), 2 in winter-spring and 1 in summer-autumn.	• As for G4 recommendations for Reach 3.

Objectives (habitat feature in parenthesis)	Main Flow Components	Flow Recommendation	Rationale
		Duration is 2 days in dry years, 5 days in average years and 8 days in wet years.	
IC4 (biofilms)	• Summer-autumn and winter-spring freshes	500 ML/d. Frequency is 1 per year in dry years and 2 per year (1 in winter-spring and 1 in summer-autumn) in average and wet years. Duration is 2 days in dry years, 5 days in average years and 8 days in wet years.	• >0.6 m/s velocity for sloughing filamentous algae (based on Ryder et al. 2006). From HECRAS: ○ Reach 1 requires than 500 ML/d. Frequency is 1 per year in dry years and 2 per year (1 in winter-spring and 1 in summer-autumn) in average and wet years.
G3 (sand and gravel bed diversity)	• Winter-spring freshes	4,400 ML/d. Frequency is 1 in 3 years for average years and annually in wet years. Duration is 1 day in average years and 2 days in wet years.	• Removal of fine-grained sediments (silts/clays) from substrates in pools. Based on shear stress (30 N/m²) required to overturn gravel substrate (particle size median) within majority of pools. From HECRAS: ○ Reach 1 requires 4,400 ML/d; mobilises sediments in 2 out of 3 pools.
IC1 (rifles)	• Winter-spring low flow	As for IC3	• Increasing the depth of low flow in winter by 0.2 m to stop excessive encroachment by terrestrial vegetation (see also objective G2). Based on HECRAS: ○ Reach 1 requires >175 ML/d.

Objectives (habitat feature in parenthesis)	Main Flow Components	Flow Recommendation	Rationale
G1, G2 (aquatic macrophytes, terrestrial encroachment)	• Low flow (all year)	As for IC3, IC4 and G3	• As for IC1 and IC2. Water level fluctuations of up to 0.2 m favours emergent aquatic macrophytes such as *Phragmites australis* (Deegan et al. 2007, Rogers and Ralph 2011) that can help to stabilise riverbanks.
G5 (bench inundation)	• Winter-spring freshes	As for G3.	• From HECRAS: ○ Reach 1 requires 4,000 ML/d (wets highest bench in the model and provide > 0.5 m depth over many benches to maintain bench form).
MI3, MI6, NF2 (invertebrate habitat, fish passage)	• Summer-autumn and winter-spring freshes	As for IC4.	• As for IC4.
NF4 (fish movement)	• Winter-spring freshes	As for G4, IC4, G3.	• Intention is for a rise in river levels of at least 0.2 m above antecedent winter low flow levels. • Magnitude covered by other objectives (e.g., G4, IC4, G3).
MI4 (biofilms)	• Winter-spring freshes	As for IC2 and IC3.	• As for IC2 and IC3.
IC6 (benches and bars)	• Winter-spring freshes	As for IC4	• As for G3 and G5.

Objectives (habitat feature in parenthesis)	Main Flow Components	Flow Recommendation	Rationale
Recommendations for Bankfull and Overbank flows			
W1 (wetlands)	• Winter-spring freshes (based on wetland commence to fill data for Reach 3)	4,000-9,000 ML/d**#** Frequency for events above 6,000 ML/d is 1 in 10 years for average years and 1 in 2 years for wet years. Duration is 1 day in average years and wet years.	• Governed by the W1 recommendation for Reach 3. • Connection occurs in average and wet years, as flows of these magnitudes do not occur in dry years. Frequency of events from 4,000-6,000 ML/d is as for objectives G3 and G5. Frequency for events of 6,000-9,000 ML/d is 1 in 10 years for average years and 1 in 2 years for wet years. • **#**Flows for Reach 1 are described as freshes due to bankfull flows being unrealistic in the confined morphology.
R1 (riparian zone)	• Winter-spring freshes (approaching bankfull flows)	As for W1.	• River Red Gum used as a surrogate for EVC 56. Both bankfull and overbank flows are recommended to ensure the needs of the understorey are met in addition to RRG. • From HECRAS: ○ Reach 1: freshes of 4,000 – 7,000 ML/d; • Flows of this magnitude would not be expected in dry years. Frequency is 1 in 10 years for average years and 1 in 2 years in wet years. Timing: spring if possible.
G6, W2, IC1, IC2, IC3, MI5, MI6, NF3	• Winter-spring freshes (approaching bankfull)	As for W1 and R1.	• Freshes approaching bankfull as for W1 and R1.

Environmental flow recommendations for reach 2 outlined in Cottingham et al (2013a)

Objectives (habitat feature in parenthesis)	Main Flow Components	Flow Recommendation	Rationale
Recommendations for Low flow			
MI1 (riffles)	• Summer-autumn low flow	Minimum flow of 40 ML/d, or natural	• From HECRAS: water to maintain runs: ○ Reach 2 requires 40 ML/d or natural
MI2 (slackwater)	• Spring-autumn low flow	Minimum flow of 30-100 ML/d, or natural (see accompanying rationale for expanded explanation) Absolute minimum of 15 ML/d (flow to persist along the length of the river)	• Meeting the needs of Reach 3 is assumed to meet the needs of Reach 2. See low flow objective MI2 in Reach 3 for full rationale.
IC5 (vegetation habitat)	• Low flow (all year)	Minimum flow of 100 ML/d, or natural	• Low flow with 0.5 m depth are based on the watering needs of *Vallisnaria* (Bowen 2006, Roberts and Marston 2011, Rogers and Ralph 2011). The watering needs of emergent vegetation (e.g., Phragmites) are expected to be catered for by the low flow for *Vallisnaria* and freshes as defined for other objectives. • Maintain 0.5 m depth in runs. From HECRAS: ○ Reach 2 requires 100 ML/d, or natural
IC3	• Low flow (all year)	As for MI1 and MI2	• As for MI1, MI2.

Objectives (habitat feature in parenthesis)	Main Flow Components	Flow Recommendation	Rationale
(vegetation encroachment on sand bars)			
NF1 (slackwater and pools)	• Summer-autumn low flow	As for MI2	• As for MI2.
NF2 (fish passage)	• Low flow (all year)	As for MI1	• Intent is 0.4 m over the shallowest point in the longitudinal profile. From HECRAS: ○ Reach 2 requires 40 ML/d.
MI3, MI6 (invertebrate habitat)	• Low flow (all year)	As for MI1 and MI2.	• As for MI1 and MI2.
G1, G2 (aquatic macrophytes, terrestrial encroachment)	• Low flow (all year)	As for MI1, MI2 and IC5	• As for MI1, MI2 and IC5.
Recommendations for Freshes			
G4 (scour around large wood)	• Summer-autumn and winter-spring freshes	400 ML/d. Frequency is 3 per year (all years), 2 in winter-spring and 1 in summer-autumn.	• Shear stress for removing fines from sediments in runs equal to 2 N/m² (based on shear stress required to mobilise sandy bed sediments in runs). From HECRAS: ○ Reach 2 requires 400 ML/d.

Objectives (habitat feature in parenthesis)	Main Flow Components	Flow Recommendation	Rationale
		Duration is 3 days in dry years, and 5 days in average and wet years.	
IC3 (vegetation encroachment on sand bars)	• Winter-spring freshes	430 ML/d. Frequency is 3 per year (all years). Duration is 3 days in dry years, and 5 days in average and wet years.	• Winter freshes. Based on HECRAS: ○ Reach 2 - features are indistinct from HECRAS, so adopt Reach 3 requirements. ○ Reach 3 requires 430 ML/d.
G3 (sand and gravel bed diversity)	• Winter-spring freshes	2,600 ML/d. Frequency is 1 in 2 years for dry years, 3 per year in average years and 5 per year in wet years. Duration is 1 day in dry years, and 2 days in average years and 4 days in wet years.	• Removal of fine-grained sediments (silts/clays) from substrates in pools. Based on shear stress (30 N/m^2) required to overturn gravel substrate (particle size median) within majority of pools. From HECRAS: ○ Reach 2 requires 2,600 ML/d.
IC4 (biofilms)	• Winter-spring freshes	4,300 ML/d. Frequency is 1 in 10 years for dry years, 2 per year for	• This will require a combination of (i) sloughing algae (freshes) and (ii) turning over cobbles (bankfull, addressed by R1, W1).

Objectives (habitat feature in parenthesis)	Main Flow Components	Flow Recommendation	Rationale
		average years and 4 per year in wet years.	• >0.6 m/s velocity for sloughing (based on Ryder et al. 2006). Based on HECRAS: ○ Reach 2 requires 4,300 ML/d. Frequency is as for objective G5.
G5 (bench inundation)	• Winter-spring freshes	4,500 ML/d. Frequency is 1 in 10 years for dry years, 2 per year for average years and 4 per year in wet years. Duration is 1 day in dry years, and 2 days in average years and 3 days in wet years.	• From HECRAS: ○ Reach 2 requires 4,500 ML/d. Frequency is 1 in 10 years for dry years, 2 per year for average years and 4 per year in wet years. ○ Duration 1-2 days, with appropriate rates of rise and fall.
IC6 (benches and bars)	• Winter-spring freshes	As for IC4	• As for G3 and G5.
NF4 (fish movement)	• Winter-spring freshes	As for G4, IC4, G3.	• Intention is for a rise in river levels of at least 20 cm above antecedent winter low flow levels. • Magnitude as for G3, IC4.
MI4 (biofilms)	• Winter-spring freshes	As for IC3.	• As for IC3.

Objectives (habitat feature in parenthesis)	Main Flow Components	Flow Recommendation	Rationale
MI3, MI6, NF2 (invertebrate habitat, fish passage)	• Summer and winter freshes	As for IC2, IC3 and IC4.	• As for IC2, IC3 and IC4.
Recommendations for Bankfull and Overbank flows			
R1 (riparian zone)	• Winter-spring freshes (approaching bankfull flows)	16,000 ML/d. Frequency is 1 in 5 years for average years and 8 in 10 years for wet years. Duration is 1 day for average and wet years.	• River Red Gum used as a surrogate for EVC 56. Both bankfull and overbank flows are recommended to ensure the needs of the understorey are met in addition to RRG. • From HECRAS: ○ Reach 2: bankfull of 16,000 ML/d; • Bankfull and overbank flows would not be expected in dry years. • Note: it is recognised that the proposition to actively manage the flows required for this recommendation will not been accepted due to Victorian policy of not inundating private land. However, it is stated here to provide completeness in terms of recommendations for maintaining or improving the conditions of ecosystem assets and values associated with the Broken River. As the current flow regime has had little effect on the natural frequency of events of this magnitude, it is expected that this recommendation will be met without active management.
W1	• Winter-spring freshes (based on wetland	As for R1	• As for R1

Objectives (habitat feature in parenthesis)	Main Flow Components	Flow Recommendation	Rationale
(wetlands)	commence to fill data for Reach 3)		
G6, W2, IC1, IC2, IC3, MI5, MI6, NF3	• Winter-spring freshes (approaching bankfull)	As for W1 and R1.	• Freshes approaching bankfull as for W1 and R1.

Environmental flow recommendations for reach 3 outlined in Cottingham et al (2013a)

Objectives (habitat feature in parenthesis)	Main Flow Components	Flow Recommendation	Rationale
Recommendations for Low flow			
MI1 (riffles)	• Summer-autumn low flow	40 ML/d, or natural.	• From HECRAS: water to maintain runs: ○ Reach 2 requires 40 ML/d or natural
MI2 (slackwater)	• Spring-autumn low flow	30-100 ML/d, or natural. Absolute minimum of 15 ML/d.	• Slackwater habitat is best defined here as depth <0.5 m and velocity <0.05 m/s (Vietz et al. 2013). Vietz et al. (2013) show the area of slackwater available in Reach 3 at different discharges (as a proportion of bankfull – approx. 20,000 ML/d). Slackwater habitat area is at its minimum at approximately 800 ML/d and at its maximum at 30-40 ML/d.

Objectives (habitat feature in parenthesis)	Main Flow Components	Flow Recommendation	Rationale
			• Dec-Apr daily flows are very similar for dry and average years (the difference between the 2 scenarios is more pronounced in winter-spring). The Dec-Apr p20 value (i.e., flows are above 100ML/day for <20% of the time) for dry and average years is approximately 100 ML/d (± approximately 20 ML/d). • The nature of discharge-slackwater habitat area is such that as discharge increases or decreases, a 50% reduction in slackwater habitat occurs outside the range of 8-120ML/day (a discharge of 8-10 ML/d represents a 33% reduction; 15 ML/d represents a 20% reduction). • Operate within range of 30-100 ML/d, or natural with an absolute minimum of 15 ML/d. • Flows outside of this range are restricted to short periods (e.g., as freshes), with appropriate rates of rise and fall).
IC5 (vegetation habitat)	• Low flow (all year)	80 ML/d, or natural.	• Low flow with 0.5 m depth are based on the watering needs of *Vallisnaria* (Bowen 2006, Roberts and Marston 2011). The watering needs of emergent vegetation (e.g., Phragmites) are expected to be catered for by the low flow for *Vallisnaria* and freshes as defined for other objectives. • Maintain 0.5 m depth in runs. From HECRAS: ○ Reach 3 requires 80 ML/d, or natural
IC3:	• Low flow (all year)	As for MI1 and MI2	• As for MI1, MI2.

Objectives (habitat feature in parenthesis)	Main Flow Components	Flow Recommendation	Rationale
(vegetation encroachment on sand bars)			
NF1 (slackwater and pools)	• Summer-autumn low flow	As for MI2	• As for MI2.
NF2 (fish passage)	• Low flow (all year)	As for MI1	• Intent is 0.4 m over the shallowest point in the longitudinal profile. From HECRAS: ○ Reach 2 requires 40 ML/d.
MI3, MI6 (invertebrate habitat)	• Low flow (all year)	As for MI1 and MI2.	• As for MI1 and MI2.
G1, G2 (aquatic macrophytes, terrestrial encroachment)	• Low flow (all year)	As for MI1, MI2 and IC5	• As for MI1, MI2 and IC5.
Recommendations for Freshes			
G4 (scour around large wood)	• Summer and winter freshes	400 ML/d. Frequency is 3-4 per year (dry, wet and average years).	• Shear stress for removing fines from sediments in runs equal to 2 N/m² (based on shear stress required to mobilise sandy bed sediments in runs). From HECRAS: ○ Reach 3 requires 400 ML/d. Frequency is 3-4 per year (dry, wet and average years).

Objectives (habitat feature in parenthesis)	Main Flow Components	Flow Recommendation	Rationale
IC3 (vegetation encroachment on sand bars)	• Winter-spring freshes	430 ML/d. Frequency is 3 per year (dry, wet and average years). Duration is 3 days in dry years, 5 days in average years and 6 days in wet years.	• Winter freshes. Based on HECRAS: ○ Reach 3 requires 430 ML/d.
G3 (sand and gravel bed diversity)	• Winter-spring freshes	1,000 ML/d. Frequency is 2 per year for dry years, 4 per year in average and wet years. Duration is 2 days in dry years, 4 days in average years and 6 days in wet years.	• Removal of fine-grained sediments (silts/clays) from substrates in pools. Based on shear stress (30 N/m²) required to overturn gravel substrate (particle size median) within majority of pools. From HECRAS: ○ Reach 3 requires 1,000 ML/d.
IC4 (biofilms)	• Winter-spring freshes	4,300 ML/d. Frequency is 1 in 10 years for dry years, 2 per year for average years and 4 per year in wet years.	• This will require a combination of (i) sloughing algae (freshes) and (ii) turning over cobbles (bankfull, addressed by R1, W1). • >0.6 m/s velocity for sloughing (based on Ryder et al. 2006). Based on HECRAS: ○ Reach 2 requires 4,300 ML/d. Frequency is as for objective G5.

Objectives (habitat feature in parenthesis)	Main Flow Components	Flow Recommendation	Rationale
		Duration is 1 days in dry years, 2 days in average years and 3 days in wet years.	
G5 (bench inundation)	• Winter-spring freshes	4,500 ML/d Frequency and duration as for IC4.	• From HECRAS: ○ Reach 2 requires 4,500 ML/d.
IC6 (benches and bars)	• Winter-spring freshes	As for IC4.	• As for G3 and IC4.
NF4 (fish movement)	• Winter-spring freshes	As for G4, IC4, G3.	• Intention is for a rise in river levels of at least 20 cm above antecedent winter low flow levels. • Magnitude as for G3, IC4.
MI4 (biofilms)	• Winter-spring freshes	As for IC3.	• As for IC3.
MI3, MI6, NF2 (invertebrate habitat, fish passage)	• Summer and winter freshes	As for IC2, IC3 and IC4.	• As for IC2, IC3 and IC4.

Objectives (habitat feature in parenthesis)	Main Flow Components	Flow Recommendation	Rationale
Recommendations for Bankfull and Overbank flows			
R1 (riparian)	• Winter-spring freshes (approaching bankfull flows)	20,000 ML/d Frequency is 1 in 10 years in average years and 7 out of 10 years in wet years. Duration is 1 day for both average and wet years.	• River Red Gum used as a surrogate for EVC 56. Both bankfull and overbank flows are recommended to ensure the needs of the understorey are met in addition to RRG. • From HECRAS: ○ Reach 3: bankfull of 20,000 ML/d; • Bankfull and overbank flows would not be expected in dry years. • Note: it is recognised that the proposition to actively manage the flows required for this recommendation will not been accepted due to Victorian policy of not inundating private land. However, it is stated here to provide completeness in terms of recommendations for maintaining or improving the conditions of ecosystem assets and values associated with the Broken River. As the current flow regime has had little effect on the natural frequency of events of this magnitude, it is expected that this recommendation will be met without active management.
W1 (wetlands)	• Winter-spring freshes (based on wetland commence to fill data for Reach 3)	As for R1	• As for R1

Objectives (habitat feature in parenthesis)	Main Flow Components	Flow Recommendation	Rationale
G6, W2, IC1, IC2, IC3, MI5, MI6, NF3	• Winter-spring freshes (approaching bankfull)	As for W1 and R1.	• Freshes approaching bankfull as for W1 and R1.

12.2 Appendix 2: Upper Broken Creek ecological objectives and flow recommendations

The following tables outlines the ecological objectives and associated flow components established for the upper Broken Creek in Jacobs (2017). These tables are to be read in conjunction with the environmental flow recommendations outlined in the table below this.

Reach 1 ecological objectives and associated flow components

Objective	Number	Function	Flow component	Timing	Expected response
Geomorphology					
Maintain channel form and where possible provide flows sufficient to mobilise sediments and maintain pools	G1.1	Minimise further sedimentation of pools	High flows	Winter/spring	Higher flows help to prevent excessive accumulation of sediment. However, flows alone are unlikely to be sufficient to significantly scour existing pools. Management of weir pools and selective excavation may be required to create deeper habitat pools.
Periodically engage distributary channels	G1.2	Engage channels to maintain drainage network	Bankfull / overbank flows		Overbank flows will spill into distributary channels helping to preserve the distributary drainage network and provide occasional inundation of off channel habitats.
Vegetation					
Promote the germination and recruitment of river red gums within the riparian zone.	V1.1	Provide soil moisture to promote germination Reduce grazing pressure on seedlings	Bankfull / overbank flows	Winter/spring	Germination and recruitment of river red gum requires overbank flows and exclusion of stock.
Maintain and promote in channel biodiversity (e.g. *Triglochin* spp)	V1.2	Scouring and maintenance of pools to provide habitat for *Triglochin* spp.	High flows	Winter/spring	*Triglochin* can survive periods of dry by persistence, is reliant on in channel pools. Flows need to be sufficient to mobilise sediment and maintain pools.
Minimise the spread of Cumbungi within the channel	V1.3	Scouring of pools	High flows	Winter/spring	Minimising the spread of Cumbungi is conditional on either prolonged drying or prolonged inundation at sufficient depth to prevent further growth.
Reduce the encroachment of riparian species (e.g. water couch) into the river channel	V1.4	Deep inundation of benches to limit growth of terrestrial species	High flows	Winter/spring	Deep inundation drowns species that prefer shallow / damp conditions.
Water Quality					
Maintain water quality	W1.1	Maintain pools during periods of low flow	Freshes	All year	Water quality should be maintained at levels that are not detrimental to aquatic biota (DO >6 mg/L)
Fish					
Maintain conditions for self-sustaining populations of small-bodied native fish	F1.1	Maintain aquatic habitat for all native fish species	Low flow	All year	Sustained populations of river blackfish, smelt, Murray River rainbowfish, Carp Gudgeons and stocked native species (Murray cod and golden perch).
Maintain conditions for survival of large-bodied native fish	F1.2	Provide migration cue and longitudinal passage for small and large-bodied native fish	High flow	Winter/Spring	Maintain population resilience to local fluctuations in abundance. Recolonization after drought conditions.
Platypus					
Maintain platypus population and support successful breeding and juvenile dispersal	P1.1	Maintain access to habitat and sufficient food resources	Low flows	All year	Low flows maintain access to habitat & provide conditions suitable for macroinvertebrates as a food source.
	P1.2	Provide opportunities for dispersal of juveniles	Freshes	Autumn	Increased flow promotes juvenile dispersal.
	P1.3	Avoid deliberate high flows in nesting season	Avoid high flow	Late spring/summer	Minimise unintended inundation of nests.
Macroinvertebrates					
Maintain self-sustaining populations of macroinvertebrates	M1.1	Maintain perennial nature of the reach. Maintain aquatic habitat including vegetation and wood.	Low flows	All year	Sustained populations of Decapoda species (shrimps).

Reach 2 ecological objectives and associated flow components

Objective	Number	Function	Flow component	Timing	Expected response
Geomorphology					
Maintain channel form and where possible provide flows sufficient to mobilise sediments and maintain channel capacity for water delivery to Moodies Swamp	G2.1	Flush accumulated sediment	High flows	Winter/spring	Higher flows help to prevent excessive accumulation of sediment. However, flows alone are unlikely to be sufficient to significantly scour existing pools. Management of weir pools and selective excavation may be required to create deeper habitat pools.
Periodically engage distributary channels	G2.2	Engage channels to maintain drainage network	Bankfull / overbank flows		Overbank flows will spill into distributary channels helping to preserve the distributary drainage network and provide occasional inundation of off channel habitats (e.g. Moodies Swamp).
Vegetation					
Promote the germination and recruitment of river red gums within the riparian zone.	V2.1	Provide soil moisture to promote germination Reduce grazing pressure on seedlings	High flows	Winter/spring	Germination and recruitment of river red gum requires overbank flows and exclusion of stock.
Maintain and promote in channel biodiversity (e.g. *Triglochin* spp)	V2.2	Scouring and maintenance of pools to provide habitat for *Triglochin* spp.	High flows	Winter/spring	*Triglochin* can survive periods of dry by persistence is reliant on in channel pools. Flows need to be sufficient to mobilise sediment and maintain pools.
Minimise the spread of Cumbungi within the channel	V2.3	Scouring of pools	High flows	Winter/spring	Minimising the spread of Cumbungi is conditional on either prolonged drying or prolonged inundation at sufficient depth to prevent further growth.
Reduce the encroachment of riparian species (e.g. water couch) into the river channel	V2.4	Deep inundation of benches to limit growth of terrestrial species	High flows	Winter/spring	Deep inundation drowns species that prefer shallow / damp conditions.
Fish					
Maintain conditions for self-sustaining populations of small-bodied native fish	F1.1	Maintain refuge aquatic habitat for all native fish species	Low flow	All year	Sustained populations of small-bodied fish and opportunistic presence of larger bodied species – cease to flows may occur but permanent pool habitat expected to remain (e.g. McLaughlin's weir).
Maintain conditions for survival / refuge habitat for large-bodied native fish - opportunistic	F1.2	Provide migration cue and longitudinal passage for small and large-bodied native fish	High flows	Winter/Spring	Maintain population resilience to local fluctuations in abundance. Recolonisation after sustained drought conditions.
	F2.3	Inundate in-channel benches and low-lying fringing vegetation	High flows	Winter/Spring	Access to spawning habitat and food resources.
Platypus					
Maintain refuge / critical feeding habitat for platypus	P2.1	Maintain pools to serve as drought refuges and assist successful downstream dispersal of juveniles	High flows	Winter/spring	High flows provide connection that fills pools serving as drought refuges and providing foraging habitat for dispersing juveniles - cease to flows may occur but permanent pool habitat expected to remain.
Macroinvertebrates					
Maintain self-sustaining populations of macroinvertebrates	M2.1	Maintain refuge aquatic habitat including vegetation and large woody debris	Low flows	All year	Sustained populations of Decapoda species (shrimps) - cease to flows may occur but permanent pool habitat expected to remain.

Reach 3 ecological objectives and associated flow components

Objective	Number	Function	Flow component	Timing	Expected response
Geomorphology					
Transition towards a series of linear wetlands	G3.1	Sediment from upstream reaches will continue to accumulate in Reach 3	NA	NA	Accumulated sediment will result in further channel constriction. Even high flows are not competent to flush accumulated material through this reach. High flows will cause inundation of low lying areas.
Vegetation					
Promote the germination and recruitment of river red gums within the riparian zone.	V3.1	Provide soil moisture to promote germination Reduce grazing pressure on seedlings	Bankfull / overbank flows	Winter/spring	Germination and recruitment of river red gum requires overbank flows and exclusion of stock.
Promote the development of a vegetation community consistent with regional wetland EVCs	V3.2	Allow occasional inundation to a variety of depths to support wetland plant biota	Freshes/High flows	Autumn / winter / spring	Germination and recruitment of wetland plant species.
Fish					
Maintain conditions for opportunistic colonisation of small-bodied native fish	F3.1	Maintain opportunistic aquatic habitat for small-bodied native fish	Freshes/High flows	Autumn / winter / spring	Opportunistic presence of small-bodied native fish e.g. smelt, Murray River rainbowfish, Carp Gudgeons.
	F3.2	Provide migration cues and longitudinal passage for small and large-bodied native fish	High flow	Winter/Spring	Maintain population resilience to local fluctuations in abundance; Recolonization after sustained drought conditions.
Platypus					
Maintain opportunities for downstream dispersal by juveniles	P3.1	Longitudinal connection that provides opportunities for downstream dispersal of juveniles	Freshes/High flows	Autumn/early Winter	High flows provide connection that fills refuge pools and promotes successful downstream dispersal.
Macroinvertebrates					
Maintain self-sustaining populations of macroinvertebrates tolerant of cease to flow periods	M3.1	Allow occasional inundation to a variety of depths to support macroinvertebrate biota tolerant of cease to flow periods	Freshes/High flows	Winter/spring	Diverse macroinvertebrate community tolerant of cease to flow periods

The following table outlines ecological objectives and flow recommendations in the upper Broken Creek Flows Study (Jacobs 2017).

Stream		Broken Creek		Reach 1	Casey's Weir to Waggarandall Weir
Compliance point		Waggarandall Weir		Gauge No.	404239 (Waggarandall Weir)
Season	Component	Volume*	Frequency	Duration	Objective
Summer / autumn (Dec-May)	Cease-to-flow	Not recommended			
	Low flow	5 ML/d (dry) 10 ML/d (avg) 10 ML/d (wet)	All season		M1.1, F1.1, P1.1
	Fresh	20 ML/d (avg) 50 ML/d (wet)	Once per year in average and wet climate years. Timed to coincide with filling Moodies Swamp. A proportion of the flow could be diverted to fill Moodies Swamp with the remainder passing to downstream reaches. Not required/expected in dry climate years.	Within the period Apr – Jun for as long as required to fill Moodies Swamp	W1.1, P1.2
	High flows	No specific recommendation but allowed to occur in response to local catchment runoff.			
Winter / spring (June-Nov)	Cease-to-flow	Not recommended			
	Low flow	10 ML/d (dry) 15 ML/d (avg) 20 ML/d (wet)	All season		M1.1, F1.1, P1.1
	Fresh	15 ML/d (dry) 20 ML/d (avg) 50 ML/d (wet)	Once per year in dry, average and wet climate years. A proportion of the flow could be diverted to fill Moodies Swamp, if a top up was required, with the remainder passing to downstream reaches.	2 weeks within the period Sep – Oct to coincide with topping up Moodies Swamp and growing period for vegetation. Duration could be longer if required to deliver water to Moodies Swamp	F1.2, P1.2, V1.2, V1.3, V1.4
	High flow / bankfull	Up to 200 ML/d	Only expected in very wet climate years once every 5 to 10 years in response to local catchment runoff. Local runoff could be augmented with transfers via Casey's Weir.	Determined by duration of local runoff. If augmentation from Casey's weir is provided, then 1-2 days.	G1.1, G1.2
	Overbank	No specific recommendation but allowed to occur in response to local catchment runoff.			

12.3 Appendix 3: Summary of priority watering actions

Upper Broken Creek – priority 1a and 1b watering action				
Target reach:	Reach 1: Reach 1 is a priority to receive environmental water in 2024-25 as it supports a more diverse and abundant native fish community than reaches 2 and 3. Reach 1 also supports a large permanent platypus population. Environmental water delivered to reach 1 will provide environmental benefits to reaches 2 and 3.			
Compliance point	Waggarandall Weir			
Potential watering action	Upper Broken Creek spring low flow: 10 ML/day Note: the low flow may be reduced to 1-9 ML/day to accommodate available water resources			
Expected watering effects	• Provides suitable water depth in the channel and good connection between weir pools for native fish and platypus. • Inundate benthic surfaces and large wood located in the bottom of the channel which provides habitat for macroinvertebrates. • Suitable water quality (DO) is maintained for native fish, platypus and macroinvertebrates. • Flow may reach the lower Broken Creek and increase the opportunity for movement of aquatic biota between the waterways.			
Environmental objectives	• Maintain conditions for self-sustaining populations of native fish. • Maintain self-sustaining populations of macroinvertebrates. • Maintain the platypus population and support successful breeding and juvenile dispersal.			
Climate scenario variations	Extreme dry	Dry	Average	Wet
Required	.	.	.	.
Volume (ML)	910	910	546	546
Assumption	Flow of 10 ML/day for 91 days 0-5 ML/day operational releases and limited or no unregulated flows. May require the release of 15 ML/day to achieve a passing flow of 10 ML/day at Waggarandall Weir	Flow of 10 ML/day for 91 days 0-5 ML/day operational releases and limited or no unregulated flows. May require the release of 15 ML/day to achieve a passing flow of 10 ML/day at Waggarandall Weir	Flow of 6 ML/day for 91 days 5-15 ML/day operational release and unregulated flows. May require the release of 6 ML/day to achieve a passing flow of 10 ML/day at Waggarandall Weir	Flow of 6 ML/day for 91 days 5-15 ML/day operational release and unregulated flows. May require the release of 6 ML/day to achieve a passing flow of 10 ML/day at Waggarandall Weir
Rationale for delivery in 2024-25	If the spring low flow is not delivered operational releases and unregulated flows may only provide limited habitat for native fish, platypus and macroinvertebrates (water depth, connectivity and quality). This may have a negative impact on their health and recruitment. A low flow of 1-9 ML/day is expected to increase the availability of habitat suitable for native fish, platypus and macroinvertebrates. This will reduce risk of poor health and recruitment outcomes.			

Upper Broken Creek – priority 1a and 1b watering action				
Target reach:	Reach 1: Reach 1 is a priority to receive environmental water in 2024-25 as it supports a more diverse and abundant native fish community than reaches 2 and 3. Reach 1 also supports a large permanent platypus population. Environmental water delivered to reach 1 will provide environmental benefits to reaches 2 and 3.			
Compliance point	Waggarandall Weir			
Potential watering action	Upper Broken Creek summer low flow: 5-10 ML/day Note: the low flow may be reduced to 1-4 ML/day to accommodate available water resources.			
Expected watering effects	• Provides suitable water depth in the channel and some connection between weir pools for native fish and platypus. • Inundate benthic surfaces and large wood located in the bottom of the channel which provides habitat for macroinvertebrates. • Suitable water quality (DO) is maintained for native fish, platypus and macroinvertebrates. • The higher flow target of 10 ML/day increases the availability of habitat and better maintains water quality (DO) during hot weather.			
Environmental objectives	• Maintain conditions for self-sustaining populations of native fish. • Maintain self-sustaining populations of macroinvertebrates. • Maintain the platypus population and support successful breeding and juvenile dispersal.			
Climate scenario variations	Extreme dry	Dry	Average	Wet
Required	.	.	.	.
Volume (ML)	720	720	270-900	270-900
Assumption	Low flow target of 5 ML/day Flow of 8 ML/day for 90 days 0-5 ML/day operational releases and limited or no unregulated flows. May require the release of 8 ML/day to achieve a passing flow of 5 ML/day at Waggarandall Weir	Low flow target of 5 ML/day Flow of 8 ML/day for 90 days 0-5 ML/day operational releases and limited or no unregulated flows. May require the release of 8 ML/day to achieve a passing flow of 5 ML/day at Waggarandall Weir	Low flow target of 5-10 ML/day Flow of 3-10 ML/day for 90 days 5-15 ML/day operational release and unregulated flows. May require the release of 3-10 ML/day to supplement operational releases and unregulated flows to achieve a passing flow of 5-10 ML/day at Waggarandall Weir	Low flow target of 5-10 ML/day Flow of 3-10 ML/day for 90 days 5-15 ML/day operational release and unregulated flows. May require the release of 3-10 ML/day to supplement operational releases and unregulated flows to achieve a passing flow of 5-10 ML/day at Waggarandall Weir
Rationale for delivery in 2024-25	Operational releases and unregulated flows may only provide limited habitat for native fish, platypus and macroinvertebrates (water depth, connectivity and quality). This may have a negative impact on their health and recruitment. A low flow of 1-4 ML/day is expected to increase the availability of habitat suitable for native fish, platypus and macroinvertebrates. This will reduce risk of poor health and recruitment outcomes.			

Upper Broken Creek – priority 1a and 1b watering action	
Target reach:	Reach 1: Reach 1 is a priority to receive environmental water in 2024-25 as it supports a more diverse and abundant native fish community than reaches 2 and 3. Reach 1 also supports a large permanent platypus population. Environmental water delivered to reach 1 will provide environmental benefits to reaches 2 and 3.
Compliance point	Waggarandall Weir
Potential watering action	Upper Broken Creek autumn low flow: 5-10 ML/day Note: the low flow may be reduced to 1-4 ML/day to accommodate available water resources
Expected watering effects	• Provides suitable water depth in the channel and some connection between weir pools for native fish and platypus. • Inundate benthic surfaces and large wood located in the bottom of the channel which provides habitat for macroinvertebrates. • Suitable water quality (DO) is maintained for native fish, platypus and macroinvertebrates.
Environmental objectives	• Maintain conditions for self-sustaining populations of native fish. • Maintain self-sustaining populations of macroinvertebrates. • Maintain the platypus population and support successful breeding and juvenile dispersal.

Climate scenario variations	Extreme dry	Dry	Average	Wet
Required	·	·	·	·
Volume (ML)	736	736	276-920	276-920
Assumption	Low flow target of 5 ML/day Flow of 8 ML/day for 92 days 0-5 ML/day operational releases and limited or no unregulated flows. May require the release of 8 ML/day to achieve a passing flow of 5 ML/day at Waggarandall Weir	Low flow target of 5 ML/day Flow of 8 ML/day for 92 days 0-5 ML/day operational releases and limited or no unregulated flows. May require the release of 8 ML/day to achieve a passing flow of 5 ML/day at Waggarandall Weir	Low flow target of 5-10 ML/day Flow of 3-10 ML/day for 92 days 5-15 ML/day operational release and unregulated flows. May require the release of 3-10 ML/day to supplement operational releases and unregulated flows to achieve a passing flow of 5-10 ML/day at Waggarandall Weir	Low flow target of 5-10 ML/day Flow of 3-10 ML/day for 92 days 5-15 ML/day operational release and unregulated flows. May require the release of 3-10 ML/day to supplement operational releases and unregulated flows to achieve a passing flow of 5-10 ML/day at Waggarandall Weir
Rationale for delivery in 2024-25	Operational releases and unregulated flows may only provide limited habitat for native fish, platypus and macroinvertebrates (water depth, connectivity and quality). This may have a negative impact on their health and recruitment. For example, juvenile platypuses require connected habitat in autumn to facilitate safe dispersal. A low flow of 1-4 ML/day is expected to increase the availability of habitat suitable for native fish, platypus and macroinvertebrates. This will reduce risk of poor health and recruitment outcomes.			
Upper Broken Creek – priority 1a and 1b watering action				
Target reach:	Reach 1: Reach 1 is a priority to receive environmental water in 2024-25 as it supports a more diverse and abundant native fish community than reaches 2 and 3. Reach 1 also supports a large permanent platypus population. Environmental water delivered to reach 1 will provide environmental benefits to reaches 2 and 3.			
Compliance point	Waggarandall Weir			
Potential watering action	Upper Broken Creek winter low flow: 10 ML/day Note: the low flow may be reduced to 1-9 ML/day to accommodate available water resources			
Expected watering effects	• Provides suitable water depth in the channel and good connection between weir pools for native fish and platypus. • Inundate benthic surfaces and large wood located in the bottom of the channel which provides habitat for macroinvertebrates. • Suitable water quality (DO) is maintained for native fish, platypus and macroinvertebrates.			
Environmental objectives	• Maintain conditions for self-sustaining populations of native fish. • Maintain self-sustaining populations of macroinvertebrates. • Maintain the platypus population and support successful breeding and juvenile dispersal. • Flow may reach the lower Broken Creek and increase the opportunity for movement of aquatic biota between the waterways.			
Climate scenario variations	Extreme dry	Dry	Average	Wet
Required	·	·	·	·
Volume (ML)	910	910	546	546
Assumption	Flow of 10 ML/day for 91 days 0-5 ML/day operational releases and limited or no unregulated flows. May require the release of 10 ML/day to achieve a passing flow of 10 ML/day at Waggarandall Weir	Flow of 10 ML/day for 91 days 0-5 ML/day operational releases and limited or no unregulated flows. May require the release of 10 ML/day to achieve a passing flow of 10 ML/day at Waggarandall Weir	Flow of 6 ML/day for 91 days 5-15 ML/day operational release and unregulated flows. May require the release of 6 ML/day to achieve a passing flow of 10 ML/day at Waggarandall Weir	Flow of 6 ML/day for 91 days 5-15 ML/day operational release and unregulated flows. May require the release of 6 ML/day to achieve a passing flow of 10 ML/day at Waggarandall Weir
Rationale for delivery in 2024-25	Operational releases and unregulated flows may only provide limited habitat for native fish, platypus and macroinvertebrates (water depth, connectivity and quality). This may have a negative impact on their health and recruitment. A low flow of 1-9 ML/day is expected to increase the availability of habitat suitable for native fish, platypus and macroinvertebrates. This will reduce risk of poor health and recruitment outcomes.			
Upper Broken Creek – priority 1b watering action				

Target reach:	Reach 1: Reach 1 is a priority to receive environmental water in 2024-25 as it supports a more diverse and abundant native fish community than reaches 2 and 3. Reach 1 also supports a large permanent platypus population. Environmental water delivered to reach 1 will provide environmental benefits to reaches 2 and 3.			
Compliance point	Caseys Weir			
Potential watering action	Upper Broken Creek year-round fresh (trigger based to manage water quality): 50 ML/day			
Expected watering effects	• Water quality (DO) is maintained for native fish, platypus and macroinvertebrates.			
Environmental objectives	• Maintain conditions for self-sustaining populations of native fish. • Maintain self-sustaining populations of macroinvertebrates. • Maintain the platypus population and support successful breeding and juvenile dispersal.			
Climate scenario variations	Extreme dry	Dry	Average	Wet
Required	·	·	·	·
Volume (ML)	500	500	500	500
Assumption	Flow of up to 50 ML/day for 10 days.	Flow of up to 50 ML/day for 10 days.	Flow of up to 50 ML/day for 10 days.	Flow of up to 50 ML/day for 10 days.
Rationale for delivery in 2024-25	This watering action may be required to manage poor water quality. This could be the result of floods, low and cease to flow events, intense rainfall and fire.			
Upper Broken Creek – priority 1b watering action				
Target reach:	Reach 1: Reach 1 is a priority to receive environmental water in 2024-25 as it supports a more diverse and abundant native fish community than reaches 2 and 3. Reach 1 also supports a large permanent platypus population. Environmental water delivered to reach 1 will provide environmental benefits to reaches 2 and 3.			
Compliance point	Caseys Weir			
Potential watering action	Winter/spring fresh: 50 ML/day			
Expected watering effects	• Increase food resources for native fish, platypus and waterbugs. • Increase flow and flush pools to improve water quality and dissolved oxygen levels. • Increase longitudinal connection that provides opportunities for downstream dispersal of juvenile platypus in early winter • Provide migration cues and longitudinal passage for native fish			
Environmental objectives	• Maintain conditions for self-sustaining populations of native fish. • Maintain self-sustaining populations of macroinvertebrates. • Maintain the platypus population and support successful breeding and juvenile dispersal.			
Climate scenario variations	Extreme dry	Dry	Average	Wet
Required	·	·	·	·
Volume (ML)			500	500
Assumption			Flow of up to 50 ML/day for 10 days.	Flow of up to 50 ML/day for 10 days.
Rationale for delivery in 2024-25	Regulation has limited the frequency, duration and magnitude of winter/spring freshes which are important for native fish and platypus recruitment and dispersal.			
Broken River – priority 1a and 1b watering action				
Target reach:	All 3 reaches			
Compliance points	• Back Creek Junction in reach 1 • Caseys Weir in reach 2 • Gowangardie Weir in reach 3			
Potential watering action	Broken River spring low flow: 15-100 ML/day			
Expected watering effects	• Permanent inundation of the channel which allows obligate submerged native plants to establish and reduces invasion of flood tolerant species. • Provides suitable water depth and flow to maintain riffles, run, pool and slackwater habitats.			

	• Suitable water quality (DO) is maintained for native fish, platypus and macroinvertebrates.			
Environmental objectives	• Maintain hydraulic habitat diversity (riffles, slackwater and pools) which supports native fish, macrophytes and macroinvertebrates.			
Climate scenario variations	Extreme dry	Dry	Average	Wet
Required	.	.	.	.
Volume (ML)	75-600	75-600	0	0
Assumption	Low flow target of 15-30 ML/day Flow of 5-40 ML/day for 15 days May require the release of 20 ML/day to achieve a passing flow of 15 ML/day at Gowangardie Weir May require the release of 40 ML/day to achieve a passing flow of 30 ML/day at Gowangardie Weir	Low flow target of 15-30 ML/day Flow of 5-40 ML/day for 15 days May require the release of 20 ML/day to achieve a passing flow of 15 ML/day at Gowangardie Weir May require the release of 40 ML/day to achieve a passing flow of 30 ML/day at Gowangardie Weir	Low flow target of 30-100 ML/day Low flow expected to be met by operational releases and unregulated flows	Low flow target of 30-100 ML/day Low flow expected to be met by operational releases and unregulated flows
Rationale for delivery in 2024-25	Operational releases and unregulated flows may only provide limited habitat for native fish, platypus and macroinvertebrates (water depth, connectivity and quality), particularly in reach 1. This may have a negative impact on their health and recruitment.			
Broken River – priority 1a and 1b watering action				
Target reach:	All 3 reaches			
Compliance points	• Back Creek Junction in reach 1 • Caseys Weir in reach 2 • Gowangardie Weir in reach 3			
Potential watering action	Broken River summer low flow: 30-100 ML/day (minimum of 15/ML/day)			
Expected watering effects	• Permanent inundation of the channel which allows obligate submerged native plants to establish and reduces invasion of flood tolerant species. • Provides suitable water depth and flow to maintain riffles, run, pool and slackwater habitats. • Suitable water quality (DO) is maintained for native fish, platypus and macroinvertebrates.			
Environmental objectives	• Maintain hydraulic habitat diversity (riffles, slackwater and pools) which supports native fish, macrophytes and macroinvertebrates.			
Climate scenario variations	Extreme dry	Dry	Average	Wet
Required	.	.	.	.
Volume (ML)	75-600	75-600	0-600	0-600
Assumption	Low flow target of 15-30 ML/day Flow of 5-40 ML/day for 15 days May require the release of 20 ML/day to achieve a passing flow of 15 ML/day at Gowangardie Weir May require the release of 40 ML/day to achieve a passing flow of 30 ML/day at Gowangardie Weir	Low flow target of 15-30 ML/day Flow of 5-40 ML/day for 15 days May require the release of 20 ML/day to achieve a passing flow of 15 ML/day at Gowangardie Weir May require the release of 40 ML/day to achieve a passing flow of 30 ML/day at Gowangardie Weir	Low flow target of 30-100 ML/day Assume operational releases and unregulated flows of approximately 60 ML/day May require the release 40 ML/day for 15 days to achieve a passing flow of 100 ML/day at Gowangardie Weir	Low flow target of 30-100 ML/day Assume operational releases and unregulated flows of approximately 60 ML/day May require the release 40 ML/day for 15 days to achieve a passing flow of 100 ML/day at Gowangardie Weir
Rationale for delivery in 2024-25	Operational releases and unregulated flows may only provide limited habitat for native fish, platypus and macroinvertebrates (water depth, connectivity and quality), particularly in reach 1. This may have a negative impact on their health and recruitment.			
Broken River – priority 1a and 1b watering action				
Target reach:	All 3 reaches			
Compliance points	• Back Creek Junction in reach 1			

	• Caseys Weir in reach 2 • Gowangardie Weir in reach 3			
Potential watering action	Broken River autumn low flow: 30-100 ML/day (minimum of 15/ML/day)			
Expected watering effects	• Permanent inundation of the channel which allows obligate submerged native plants to establish and reduces invasion of flood tolerant species. • Provides suitable water depth and flow to maintain riffles, run, pool and slackwater habitats. • Suitable water quality (DO) is maintained for native fish, platypus and macroinvertebrates.			
Environmental objectives	• Maintain hydraulic habitat diversity (riffles, slackwater and pools) which supports native fish, macrophytes and macroinvertebrates.			
Climate scenario variations	Extreme dry	Dry	Average	Wet
Required	·	·	·	·
Volume (ML)	75-600	75-600	0-600	0-600
Assumption	Low flow target of 15-30 ML/day Flow of 5-40 ML/day for 15 days May require the release of 20 ML/day to achieve a passing flow of 15 ML/day at Gowangardie Weir May require the release of 40 ML/day to achieve a passing flow of 30 ML/day at Gowangardie Weir	Low flow target of 15-30 ML/day Flow of 5-40 ML/day for 15 days May require the release of 20 ML/day to achieve a passing flow of 15 ML/day at Gowangardie Weir May require the release of 40 ML/day to achieve a passing flow of 30 ML/day at Gowangardie Weir	Low flow target of 30-100 ML/day Assume operational releases and unregulated flows of approximately 60 ML/day May require the release 40 ML/day for 15 days to achieve a passing flow of 100 ML/day at Gowangardie Weir	Low flow target of 30-100 ML/day Assume operational releases and unregulated flows of approximately 60 ML/day May require the release 40 ML/day for 15 days to achieve a passing flow of 100 ML/day at Gowangardie Weir
Rationale for delivery in 2024-25	Operational releases and unregulated flows may only provide limited habitat for native fish, platypus and macroinvertebrates (water depth, connectivity and quality), particularly in reach 1. This may have a negative impact on their health and recruitment. For example, juvenile platypuses require connected habitat in autumn to facilitate safe dispersal.			
Broken River – priority 1a and 1b watering action				
Target reach:	All 3 reaches			
Compliance points	• Back Creek Junction in reach 1 • Caseys Weir in reach 2 • Gowangardie Weir in reach 3			
Potential watering action	Broken River winter low flow: 30-100 ML/day (minimum of 15/ML/day)			
Expected watering effects	• Permanent inundation of the channel which allows obligate submerged native plants to establish and reduces invasion of flood tolerant species. • Provides suitable water depth and flow to maintain riffles, run, pool and slackwater habitats. • Suitable water quality (DO) is maintained for native fish, platypus and macroinvertebrates.			
Environmental objectives	• Maintain hydraulic habitat diversity (riffles, slackwater and pools) which supports native fish, macrophytes and macroinvertebrates.			
Climate scenario variations	Extreme dry	Dry	Average	Wet
Required	·	·	·	·
Volume (ML)	75-600	75-600	0	0
Assumption	Low flow target of 15-30 ML/day Flow of 5-40 ML/day for 15 days May require the release of 20 ML/day to achieve a passing flow of 15 ML/day at Gowangardie Weir	Low flow target of 15-30 ML/day Flow of 5-40 ML/day for 15 days May require the release of 20 ML/day to achieve a passing flow of 15 ML/day at Gowangardie Weir	Low flow target of 30-100 ML/day Low flow expected to be met by operational releases and unregulated flows	Low flow target of 30-100 ML/day Low flow expected to be met by operational releases and unregulated flows

	May require the release of 40 ML/day to achieve a passing flow of 30 ML/day at Gowangardie Weir	May require the release of 40 ML/day to achieve a passing flow of 30 ML/day at Gowangardie Weir		
Rationale for delivery in 2022-23	Operational releases and unregulated flows may only provide limited habitat for native fish, platypus and macroinvertebrates (water depth, connectivity and quality), particularly in reach 1. This may have a negative impact on their health and recruitment.			
Broken River – priority 1b watering action				
Target reach:	All 3 reaches			
Compliance points	• Back Creek Junction in reach 1 • Caseys Weir in reach 2 • Gowangardie Weir in reach 3			
Potential watering action	Broken River summer or autumn fresh: 400-500 ML/day for 2 days			
Expected watering effects	• Provide sufficient critical shear stress to turn over bed sediments, scour around large wood and remove biofilm • Provide a mosaic of habitats suitable for macrophyte colonisation. • Provide flow of sufficient magnitude to stimulate native fish breeding and movement. • Provides suitable water depth and increase habitat connectivity to promote fish passage.			
Environmental objectives	• Turn over bed sediments and scour around large wood. • Provide flow cues to stimulate native fish breeding and migration movements. • Promote biofilm productivity. • Maintain macrophyte habitat. • Provide habitat for native fish passage.			
Climate scenario variations	Extreme dry	Dry	Average	Wet
Required	NA	.	.	.
Volume (ML)	0	1,910-2,790	1,910-2,790	1,910-2,790
Assumption	Would not naturally occur under the extreme dry climate scenario	Flow of 400-500 ML/day for 2 days with rates of rise and fall and a base flow of 60 ML/day	Flow of 400-500 ML/day for 2 days with rates of rise and fall and a base flow of 60 ML/day	Flow of 400-500 ML/day for 2 days with rates of rise and fall and a base flow of 60 ML/day
Rationale for delivery in 2024-25	Since 2011 reach 1 has only had 3 recommended summer/autumn fresh and reaches 2 and 3 have had 8 and 9 respectively. Not delivering the fresh may have a negative impact on the health and recruitment of macrophytes, native fish and macroinvertebrates.			

1a Critically important actions that should be partly or completely achievable based on estimates of available water resources

1b Critically important actions that are unlikely to be achievable based on estimates of available water resources

2 Actions expected to improve environmental outcomes, but are unlikely to result in negative environmental outcomes if they are not delivered this year