Seasonal Watering Proposal for the Wimmera River System 2022-23

Report prepared for: **Victorian Environmental Water Holder**
Report prepared by: Wimmera CMA
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High unregulated flows in the Wimmera River at Horsham Weir, November 2021

GLOSSARY

Baseflows: low flows, volumes that constitute a baseflow according to environmental flow recommendations vary depending on the season and achieve objectives around water quality and fish.

Freshes: larger flow events mimicking storm events, volumes that constitute a fresh according to environmental flow recommendations vary depending on the season and achieve objectives around water quality, vegetation diversity and fish.

Bankfull/Overbank: Much higher flows that fill or overtop the river channel in places that typically occur during natural very wet spells that are important for functions like watering riparian vegetation and preventing channel constriction.

Passing flows: portion of inflows that must be released at harvesting infrastructure (Huddleston's Weir, Lake Lonsdale, Fyans Creek, Rocklands Reservoir).

Carryover: unused allocations from the previous water year minus a deduction for evaporation

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Executive summary

Rainfall conditions in 2021-22 were fair although once again well below historic averages for inflows. Rain from late autumn through to spring was reasonably regular and occasionally quite intense. Although there were stretches (e.g. July and September) that were drier than average and so catchments that were primed started to dry out, limiting the runoff generated. There was also a spatial discrepancy in rainfall with the upper Wimmera catchment experiencing much better rainfall proportionally than catchments further west such as the Grampians and Black Ranges. Therefore the Wimmera River experienced its most consistent natural flows since 2016, lasting from early winter to early summer, precluding the need to release environmental water until January 2022. These natural flows provided good opportunities for the dispersal of biota as well as mobilising the high carbon loads in the river near Dimboola following the January 2021 blackwater event. This sparked a burst of life with fish and macroinvertebrates breeding in large numbers.

The lack of suitable and plentiful water has affected the outcomes on lower parts of the MacKenzie River and Mt William and Burnt Creeks although there are still some significant values remaining such as Western Swamp Crayfish in the lower Burnt Creek. Other waterways such as the Burnt Creek and MacKenzie River also saw consistent but not substantial flows in their upper reaches which helped to generate positive outcomes such as platypus breeding. The Ranch Billabong continues its trajectory of improvement after another watering with enhanced water quality and vegetation attracting a wide variety of birdlife.

Flows, whilst reasonably continuous across the catchment, were not substantial and so inflows into storages were again around the bottom 10% of inflow years. This, combined with the ability to make water savings due to not needing to release flows for the Wimmera River until early 2022 means that environmental water availability essentially remains in a holding pattern. There is enough to protect priority environmental values in most cases for the coming year but not achieve more than that (assuming conditions remain dry) without running a very high risk of having substantial shortfalls heading into 2023-24.

These achievements of 2021-22 to date include:

- the maintenance of a high value fish and crayfish populations in the MacKenzie River and Burnt Creek after another year of watering targeted at priority refuge pools;
- numerous anecdotal reports that the Wimmera River is fishing as well as it has for many years with plenty of robust native fish caught and spawning/recruitment activity noted;
- although some events were cancelled or severely limited due to COVID-19 protocols, there were still several very successful Wimmera River-based events.

This proposal is for the use of available water in the Wimmera Catchment to maximise environmental outcomes in 2022-23 to continue to prevent critical losses if the catchment remains dry or enhance conditions if wetter conditions prevail. The proposal focuses on the regulated waterways of the lower Wimmera River, Burnt Creek, MacKenzie River, Bungalally Creek and Mt William Creek as well as Ranch Billabong and Dock Lake. The delivery of environmental water to these waterways is intended to support the environmental assets within these waterways such as riparian vegetation, iconic Freshwater Catfish and Platypus populations, locally vulnerable Southern Pygmy Perch and River Blackfish populations and threatened species such as Glenelg Spiny Crayfish and Western Swamp Crayfish. These waterways also contain many shared benefits including important cultural heritage sites, provide water for agriculture and public open spaces and sustains a variety of recreational activities like fishing, swimming and boating.

Assuming the continuation of dry conditions, the focus for 2022-23 is again to protect high value refuge habitat and mitigate water quality declines (especially salinity) through baseflows and freshes particularly in summer/autumn. This in turn reduces the likelihood of fish deaths, algal blooms and die back of fringing vegetation. Should conditions be wetter, than the objective is to pursue vegetation and fish recruitment objectives by implementing more continuous baseflows and numerous freshes, especially in spring. Vegetation recruitment objectives are provided by implementing baseflows to maintain edge habitats and freshes to maintain existing plants, promote the establishment of new seed/plants in the growing season and maintain and encourage germination of aquatic plants.

Five management scenarios have been developed to cover the range of possible climatic conditions. These scenarios and associated watering actions are outlined in Table 25. A wide variety of shared benefits will be provided by environmental watering actions, including watering for cultural outcomes at The Ranch in Dimboola as well as the recreational activities the Wimmera River provides that lead to enormous positive socio-economic and health outcomes for the region.

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Unregulated flows on the Wimmera River at Glenorchy Weir, November 2021

1. Introduction

1.1 Background

Environmental entitlements are available to be released from storages when needed and delivered to waterways to protect or enhance their environmental values and condition. They also lead to a number of broader social, cultural and economic benefits as well. In the Wimmera, environmental entitlements are held by the Victorian Environmental Water Holder (VEWH) and the Commonwealth Environmental Water Holder (CEWH). The Wimmera Catchment Management Authority (Wimmera CMA) is responsible for ensuring environmental water is delivered to rivers, streams and wetlands in its region through developing and submitting seasonal watering proposals to the VEWH for consideration and managing the delivery of environmental water in accordance with the VEWH's seasonal watering statements and agreements with the CEWH.

The VEWH prepares a statewide seasonal watering plan each water (financial) year. The plan describes the desired environmental water use for rivers and wetlands across Victoria in the coming year, based on seasonal watering proposals submitted by CMAs and Melbourne Water. The VEWH then prepares seasonal watering statements that authorise these organisations to undertake the agreed watering activities. As water availability and seasonal conditions change, the VEWH may prepare additional seasonal watering statements.

In the unlikely event there be any allocation to the CEWH in 2022-23, a new agreement will need to be developed between Wimmera CMA, CEWH and VEWH around water delivery given the expiry of the original one.

1.2 Purpose

The purpose of the Seasonal Watering Proposal for the Wimmera System is to:

- identify the environmental water requirements of the lower Wimmera River, MacKenzie River, Burnt Creek, Mt William Creek, Bungalally Creek and Dock Lake in the coming year under a range of climatic scenarios to protect or improve their environmental values and health;
- inform the development of environmental water priorities in the VEWH's seasonal watering plan; and
- Inform the development of CEWH plans for its portfolio management in 2022-23.

The proposal is informed by scientific studies and reports that identify the flow regimes required to meet the ecological objectives of the priority waterways. This proposal was prepared in consultation with key stakeholders and partners and has been approved by the Wimmera CMA. It is required under section 192A of the *Water Act 1989*.

1.3 System Overview

Located in western Victoria, the Wimmera River has a total catchment area of 24,011 km^2. Regulated waterways within the Wimmera River catchment include the lower Wimmera River, MacKenzie River, Burnt Creek, Mt William Creek and Bungalally Creek. A proportion of flow in the Wimmera River also flows up the Yarriambiack Creek – a distributary creek. Refer to Figure 1 for the location of these waterways. Stretches of the Wimmera River and MacKenzie Rivers have been reserved as National Park, State Park and Natural Features Reserves. Sections of the lower Wimmera River are listed under the *Heritage Rivers Act 1992* and are subject to Native Title. Ranch Billabong is a flood-runner/anabranch wetland located adjacent to the Wimmera River at Dimboola.

These waterways support a diverse and abundant native fish community including Freshwater Catfish, River Blackfish, Southern Pygmy Perch, Australian Smelt, Flat-headed Gudgeon, Common Galaxias, Carp Gudgeon, Obscure Galaxias, Golden Perch and Silver Perch. Occasional captures of Murray Cod and Short-finned Eels have been noted too. The associated floodplain habitats support largely Red Gum-dominated grassy woodland communities, and numerous threatened species of state and national conservation significance. The waterways and associated floodplain habitats also contain many important cultural heritage sites, provide water for agriculture and public open spaces, and support a variety of recreational activities such as fishing and bushwalking. More detail around the Wimmera River system is available in the *Wimmera River System Environmental Water Management Plan* (EWMP) (Wimmera CMA, 2015). The EWMP will be updated in coming years to incorporate the learning from recent work on wetlands in the system (Dock Lake and the Terminal Lake system) and to improve the links with other environmental water planning documents.

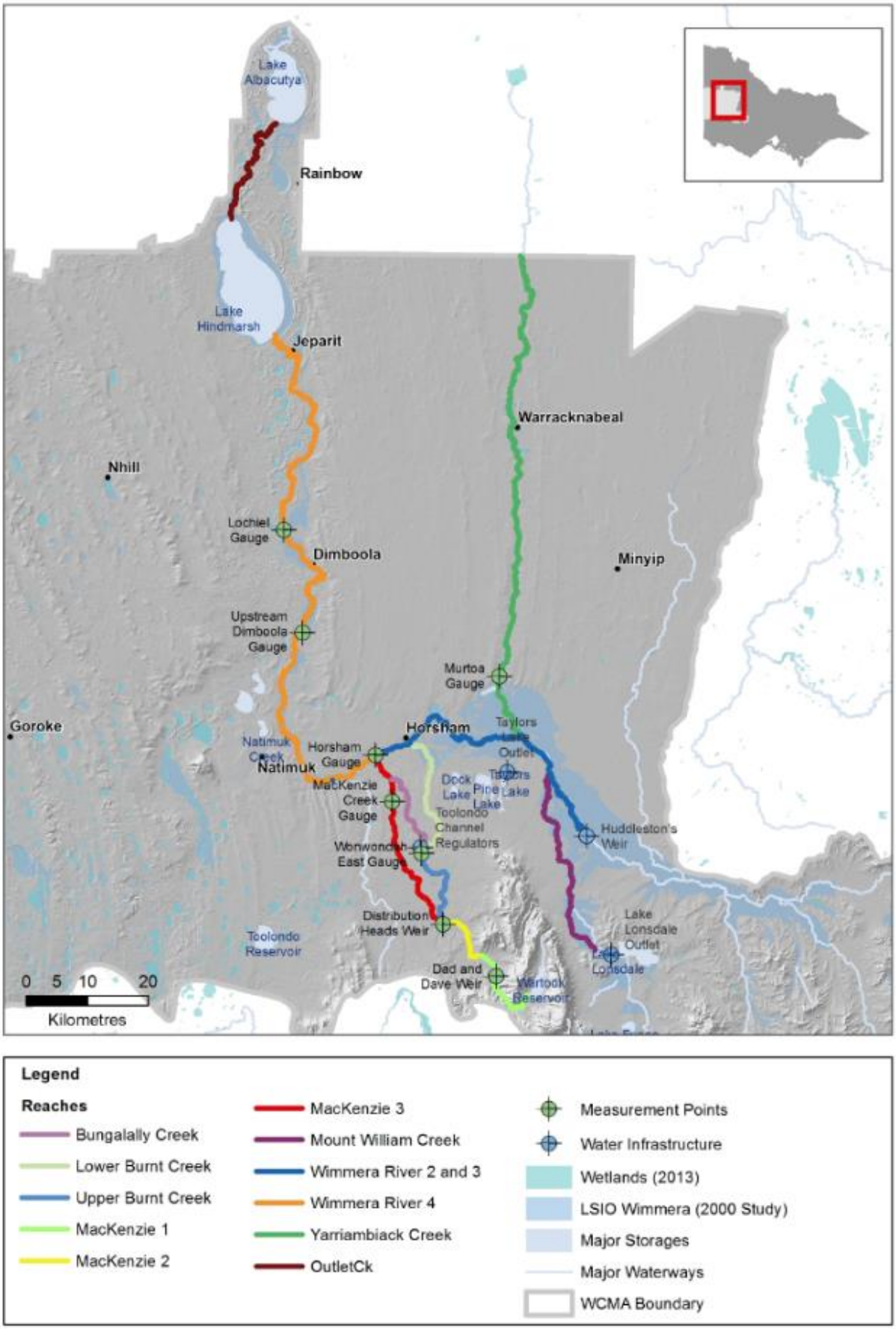


Figure 1. Wimmera system reaches, measurement points and target locations.

1.4 Flow Regime

All of the waterways covered in this proposal have been regulated for decades, significantly altering their flow regimes. Under natural conditions these waterways would receive much greater flows, particularly during winter/spring. The rivers and creeks have been further modified in the past 200 years by processes like channel incision, infilling of deep pools with sediment and dryland salinity. This means that releasing environmental water is vital for supporting and enhancing their environmental values as well as providing cultural and recreational benefits. More detail around the flow regime and characteristics for these waterways is available in the *Wimmera River System Environmental Water Management Plan* (Wimmera CMA, 2015).

1.5 Priority reaches and measuring points

Environmental flow recommendations for regulated waterways in the Wimmera Catchment were initially developed in 2003. They were revised in 2013 to provide more relevant environmental objectives that were endorsed by a community advisory group as well as considering knowledge obtained after drought and floods and the completion of the Wimmera Mallee Pipeline Project (Table 1). It remains a solid foundation for decision making and instead of static annual recommendations of the 2003 work, now includes adaptable components based on different climatic conditions (drought, dry, average and wet). Flow recommendations for upper Mt William Creek are based on work completed in 2005. To facilitate the flow volume determination, process the waterways were divided into reaches with similar channel morphology, flow regimes and ecological values (Figure 1). Refer to the table below for the priority waterway reaches, compliance monitoring points, flow recommendations and report references.

Table 1. Summary of waterway reaches, compliance points and flow study reference.

Waterway reach	Compliance point	Key ecological values identified	FLOWS Study
Lower Wimmera River Reach 2	Horsham 415200	Contains a self-sustaining population of Freshwater Catfish. Golden Perch and Silver Perch are also present (stocked). High quality macroinvertebrate population within well-vegetated sections. Supports abundant native fish, waterbirds, turtle, frog and rakali populations.	Alluvium 2013
Lower Wimmera River Reach 3			Alluvium 2013
Lower Wimmera River Reach 4	Lochiel Railway Bridge 415246		Alluvium 2013
Lower Burnt Creek	No current compliance point	Contains sections of valuable riparian vegetation which provides important habitat connectivity for terrestrial and aquatic species. Recent fish monitoring indicates that high value fish species are present which warrants a review of management objectives and flow recommendations.	Alluvium 2013
Upper Burnt Creek	East Wonwondah 415223	Very high variety and proportion of native fish including River Blackfish, Southern Pygmy Perch, Obscure Galaxias. Key location for Southern Pygmy Perch and Obscure Galaxias breeding. Contain a regionally vulnerable Western Swamp Crayfish population. High quality macroinvertebrate population within well vegetation sections.	Alluvium 2013
Upper Mt William Creek	None applicable	Very high proportion of native fish including River Blackfish, Southern Pygmy Perch, Obscure Galaxias. Key location for breeding Southern Pygmy Perch, River Blackfish and Obscure Galaxias. Contain a regionally vulnerable Western Swamp Crayfish population (Ecology Australia, 2017b). Good quality vegetation within National park boundaries with remnant vegetation along the rest of the waterway.	SKM 2005
Lower Mt William Creek	Lake Lonsdale tail gauge 415203		Alluvium 2013
Bungalally Creek	No current compliance point	Contains sections of valuable riparian vegetation which provides important habitat connectivity for terrestrial and aquatic species.	Alluvium 2013
MacKenzie River Reach 1	No current compliance points	Regionally valuable Platypus population which has shown evidence of breeding. Very high proportion of native fish including River Blackfish, Southern Pygmy Perch and Obscure Galaxias. Contain a regionally vulnerable Glenelg Spiny Crayfish population (Ecology Australia, 2017b). Good quality vegetation within national park boundaries with remnant vegetation along the rest of the waterway. Excellent quality macroinvertebrate population.	Alluvium 2013
MacKenzie River Reach 2			
MacKenzie River Reach 3	McKenzie Creek Reserve 415251	Contains sections of valuable riparian vegetation which provides important habitat connectivity for terrestrial and aquatic species. Also contains good populations of Obscure Galaxias and Southern Pygmy Perch when it contains water.	Alluvium 2013

1.7 Water sources

Water available for use in the lower Wimmera River, MacKenzie River, Burnt Creek, Mt William Creek, Bungalally Creek, Ranch Billabong and Dock Lake include:

- regulated environmental entitlements held by the VEWH and the CEWH
- unregulated flows; and
- passing flow requirements as detailed in Table 1 in Schedule 1 of the *Wimmera and Glenelg Rivers Environmental Entitlement.*

Forecasts for regulated water availability in comparison to priority watering actions are included in Table 2. In addition to these sources there are periodic transfers between headworks storages which provide environmental benefits.

Table 2. Environmental water volumes required for priority watering actions and forecast allocations for 2022/23 water year under a range of climatic scenarios.

WIMMERA REGULATED WATERWAYS Inflow Probability of Exceedance (likelihood of inflows being more than % indicated)	DROUGHT 95%	VERY DRY 90%	DRY 75%	AVERAGE 50%	WET 20%
Forecast carryover (ML) to share between the Wimmera and Glenelg Systems	19,723	19,723	20,413	21,792	24,205
Current forecast environmental allocation (ML) for the Wimmera and Glenelg Systems (not including Glenelg compensation flow)	5,678	12,574	23,119	32,854	40,560
Environmental water indicated as available to deliver Tier 1a priority watering actions (ML) for the Wimmera System	7,000	8,000	11,500	16,500	21,500
Forecast environmental water (ML) for the Wimmera and Glenelg Systems in 2023/24 (not including Glenelg compensation flow)	11,900	16,150	19,550	23,800	27,200

2. Engagement

Consultation with key stakeholders in developing this proposal is summarised in Table 3. In addition to consultation listed in Table 3, Wimmera CMA have had regular discussions with stakeholders and community members including recreational users prior to and during the implementation of water releases. Day-to-day environmental release operations are communicated to the public via a registered SMS service. Quarterly media updates have been published in local newspapers, on the Wimmera CMA website and on social media to update the community regarding environmental releases planned and delivered and subsequent environmental outcomes. Examples of media updates developed are included in Appendix 1.

COVID-19 continued to affect the way Wimmera CMA engages with community members and stakeholders in 2021-22 and limited opportunities for more 'traditional' engagement such as community meetings. The results were mixed, with the opportunity to continue to reach stakeholders more at the periphery of the environmental watering program being a pleasing outcome but the inability to maintain the dialogue with key stakeholders and community members in a face to face format was less than ideal. Examples include:

- Instead of the annual Environmental Water Management Forum (usually held in August/September in Dimboola or Horsham) Wimmera CMA sent letters to invitees outlining plans for 2021-22 and seeking feedback to inform future watering events (i.e. 2022-23);
- A community event called *PB&J – Platypus, Breakfast and Josh* was held in late April 2021 at Wartook near the MacKenzie River. It provided a great opportunity for the community to come together after a year of lockdowns and limited social interations. Josh Griffiths from cesar spoke about the amazing characteristics of platypuses and their pattern of distribution in the Wimmera, particularly in response to environmental water.
- Meetings with environmental watering partners like Barengi Gadjin Land Council, GWMWater and Parks Victoria transitioned to online formats such as Microsoft Teams; and
- Engagement with anglers has been a focus in 2021-22 as part of the development of the *Wimmera Native Fish Management Plan* by ARI. This has involved gaining feedback from members of the plan's reference group on ways flows can affect fish populations and behaviour.

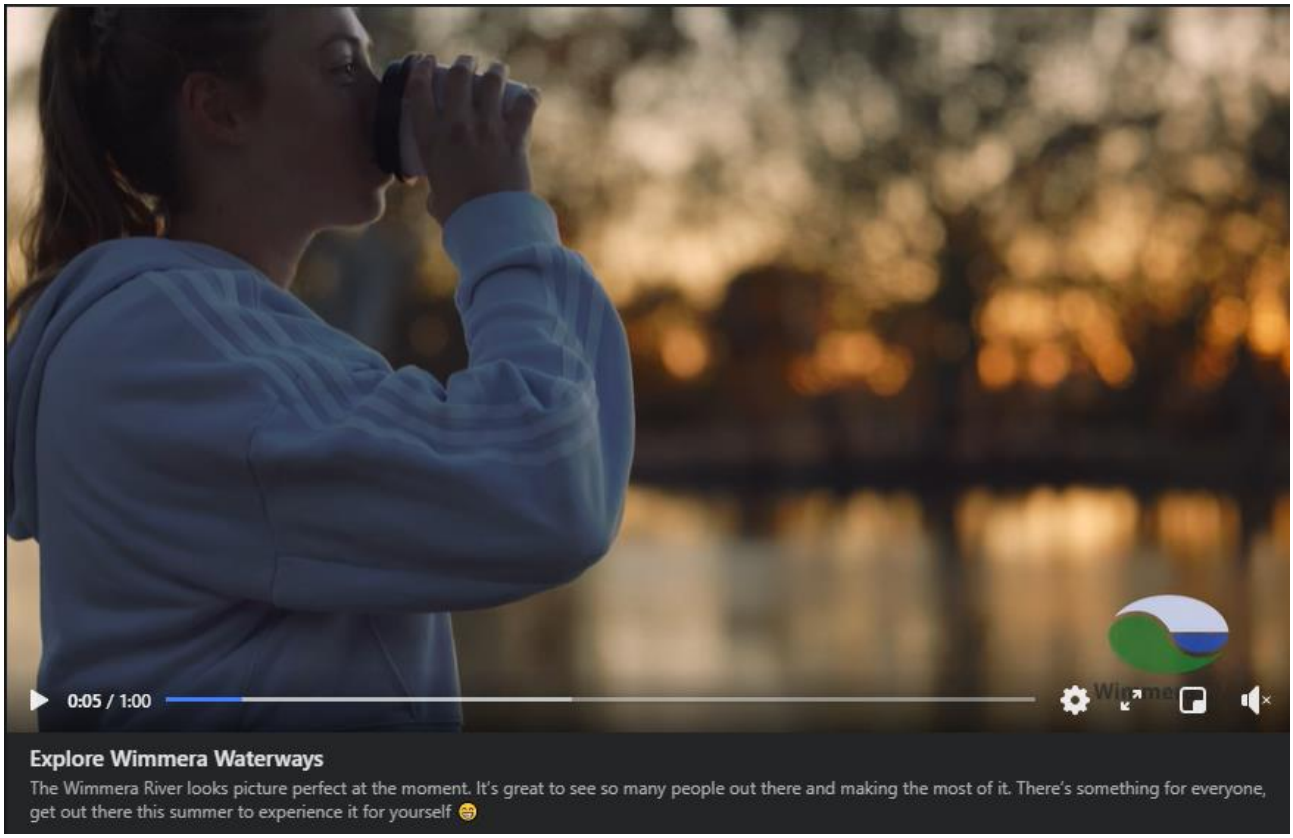
Table 3. Consultation undertaken regarding environmental water management for the Wimmera River System.

Who		IAP2 Engagement	Purpose of consultation	Form and timing of consultation	Issues identified/comments
Wimmera CMA	Wimmera CMA Board	NA	Informing the Board regarding actions and communication approaches.	Monthly updates of EWR actions in Board reports. Review and approve draft Seasonal Watering Proposal	Minor edits required for finalisation
Program Partners	VEWH	Collaborate	Involve VEWH in development of proposal to assist with aligning document with VEWH requirements	Direct engagement and via formal advisory groups (meetings between Glenelg Hopkins CMA, GWMWater, Wimmera CMA & VEWH, throughout the year such as during Storage Manager Reference Group and Western Rivers Advisory Group).	Discussion of the likely seasonal forecast for environmental water allocation, priority watering actions for a range of environmental allocations and risk management issues.
	Glenelg Hopkins CMA		Justification for water use in Wimmera River system		
	GWMWater		Consult with storage manager to identify operational issues with proposed releases and likely resource availability under different scenarios	Direct engagement and via formal advisory groups. The WCMA are constantly consulting with GWMWater regarding the seasonal outlook, improvements to monitoring and delivery of priority watering actions through the Storage Manager Reference Group, and directly.	It is important to receive feedback on water delivery constraints, planned maintenance and upgrades etc. to inform the proposal.
	DELWP		Communicate environmental monitoring outcomes, research project outcomes and project delivery for a number of projects.	Direct engagement (periodic phone conversations and e-mail updates).	DELWP fund a number of projects associated with environmental water delivery and engagement in the region.
	CEWH		Discuss proposed watering actions that can include CEWH water in the unlikely event that it is available in 2022-23 given dry conditions.		Need to understand local priorities to inform portfolio management and determine outcomes of watering activities.
	MDBA	Consult	Highlight risks and outcomes associated with environmental watering		Understanding local conditions helpd with reporting/information at a MDB scale (e.g. water quality alerts)
Councils and Agencies	Yarriambiack Shire Council	Consult	Discuss likely flow regimes for the Wimmera River and the impact this has on the Yarriambiack Creek	Direct engagement and via formal advisory groups. Attend Yarriambiack Creek Advisory Committee meetings.	See Yarriambiack Creek Advisory Committee
	Northern Grampians Shire Council		Outline planned flow regimes for the Mt William Creek	Periodic contact throughout the year and via annual environmental watering forum e.g. e-mails/phone calls around Mt William Creek flows.	The impact of environmental flows on levels in Lake Lonsdale is an ongoing concern to the council.
	Hindmarsh Shire Council	Involve	Work with council to manage weir heights to facilitate events whilst enabling flows to pass downstream and mitigating erosion in the weir pool. Also to communicate proposed environmental watering actions and seasonal outlook in relation to likely environmental water allocation for 2022-23.	Periodic contact throughout the year regarding weir management such as via onsite meetings, e-mails and via annual environmental watering forum.	Councils are very interested in environmental water allocations available and its impact on the region's economy, tourism and the environment. Also weir management for events, maintenance works, erosion issues etc. is an ongoing requirement.
	Horsham Rural City Council (HRCC)				
	Victorian Fisheries Authority	Consult	Victorian Fisheries Authority are interested in environmental watering activities to inform fish stocking and population dynamics.	Periodic contact throughout the year and via annual environmental watering forum.	Useful to share information on fish population responses
	Parks Victoria		Parks Victoria are interested in monitoring outcomes and flows relating to land they manage in the Grampians and the Wimmera Heritage River sections.	Periodic contact throughout the year and via annual environmental watering forum.	Further consultation with local PV staff will help identify opportunities around complementary onground works and enhance their understand of the environmental watering process.
Environmental Groups	Yarriambiack Creek Advisory Committee	Consult	Discuss likely flow regimes for the Wimmera River and the impact this has on the Yarriambiack Creek	Direct engagement and via formal advisory groups. Attend Yarriambiack Creek Advisory Committee meetings.	The committee has been in recess for two years
	Friends of Bungalally and Burnt Creek Group		Consult with members of the group in relation to flows for Bungalally Creek and Burnt Creek.	Direct engagement. Periodic discussions with group members and attend meetings throughout the year when requested.	Keen to see more flows along the Bungalally and Burnt Creek. Timing of lower Burnt Creek flows to fill pools is important given low water availability in Lake Wartook.
Recreational users	Lake Lonsdale Action Group	Consult	Discuss impact of releases on storage levels with respect to recreation, water quality etc.	Direct engagement and via environmental watering forum. Regular discussions with members and attend meetings throughout the year when requested.	The Lake Lonsdale Action Group want to ensure that environmental water is supplied by a series of storages to share the impacts on water levels. Should conditions remain dry very little to no water will be able to be sourced from Lake Lonsdale.
	Field and Game		Communicate proposed environmental watering actions and seasonal outlook in relation to likely environmental water allocation for 2021/22 next watering year.	Contacted Natimuk Field and Game via e-mail with offer to review draft seasonal watering proposal	NA
	VRFish			Invite to attend annual environmental watering forum.	Interested in fish outcomes from ongoing environmental watering
	Natimuk Lake Water Ski Club			Periodic contact throughout the year and via annual environmental watering forum.	Wimmera CMA has worked with the club and HRCC to maximise weir pool levels in Horsham for ski events that were followed by releasing additional water from the weir pool.
	Dimboola Water Ski Club			Periodic contact throughout the year and via annual environmental watering forum.	Ski club has been undertaking revegetation works to reduce erosion impacts of water skiing. Management of the weir pool level as been important in allowing vegetation to establish. Also the water levels in Dimboola Weir Pool are important for the very successful Peter Taylor Memorial Compeititon.
	Dimboola Fishing Classic			Periodic contact throughout the year and via annual environmental watering forum.	Flows will help the event's appeal should it go ahead in spring 2022.
	Horsham Triathlon Committee			Periodic contact throughout the year and via annual environmental watering forum.	The triathlon remains in recess due to a lack of numbers on the organising committee.
	Wimmera Anglers' Association			Periodic contact throughout the year and via annual environmental watering forum.	Infrequent discussions occur to share information in particular around instream woody habitat and water levels
	Dimboola Rowing Club			Periodic contact throughout the year and via annual environmental watering forum.	Infrequent discussions occur to share information around planned flows for November regatta.
	Jeparit Anglers' Club			Periodic contact throughout the year, including phone calls, e-mails and via annual environmental watering forum.	Feedback has been that conditions are fine for the Easter competition to go ahead in 2022.

Who		IAP2 Engagement	Purpose of consultation	Form and timing of consultation	Issues identified/comments
	Hindmarsh Ski Club			Invitation to annual environmental watering forum.	Club appears to be in recess given low water levels in Wimmera River and Lake Hindmarsh is dry.
	Horsham Fishing Competition Committee		Water level remain stable in the lead up to the event to remove misconception that environmental flows affect the number of fish caught at the competition	Periodic contact throughout the year, including phone calls, e-mails and via annual environmental watering forum.	Kept committee informed regarding the impact of environmental flows in January and February on weir pool levels.
	Canoeing Victoria		Highlight the value of the Wimmera River for potential canoeing events given the positive impact of environmental watering on water levels.	Periodic contact via e-mail	There have been annual kayak/canoe guide training/accreditation sessions held in the Wimmera River at Horsham
Traditional Owners	Barengi Gadjin Land Council	Collaborate	Consult with the council regarding environmental water delivery and communicate likely deliveries for next season and next watering year. Obtain information around cultural values where available.	Online meeting with BGLC staff on 22 February to discuss plans and contact throughout the year as part and via annual environmental watering forum. Fortnightly meetings about BGLC and CMA shared interests.	Supportive of the continuation of actions seen in 2021-22 continuting in 2022-23. Timing of Ranch Billabong looking to be August to fit in with calendar of events. Potential project to address water quality issues in Ranch Billabong to be scoped for potential funding.
Landholders/ farmers	Wimmera community members, especially landholders and stock and domestic water users	Inform	Consult with community on environmental water delivery, particularly of those from storages with high recreational value, and communicate likely deliveries for next season and next watering year. Raise community awareness regarding environmental water releases.	Media releases and advertisements have been published in local newspapers and on our web site.	Important to give the community knowledge of what environmental flows are being delivered, environmental benefits recorded and provide an opportunity for discussion and feedback.
			Inform community (especially landholders) around flows and changes to flow rates.	Direct engagement on flow changes via SMS or indirect via CMA webpage	Some landholders appreciate being notified of flows being released to inform stock movement. Anglers appreciate updates around freshes given they have noted fish are more active when freshes occur. Stock and domestic water users are affected by low water levels with pump priming issues.

Stormy skies provided a dramatic backdrop to the Australia Day waterski demonstration on the Wimmera River in Horsham.

There is also ongoing engagement with stakeholders (e.g. Barengi Gadjin Land Council, local government and fishing competition committees) about environmental flows where relevant. It should also be noted that Wimmera CMA regularly participates in a number of groups and committees that provide an opportunity to exchange information around environmental watering actions and outcomes.



Wimmera CMA produced a very popular clip in December 2021 encouraging the community to get out and enjoy the Wimmera River's many recreational aspects
(https://www.youtube.com/watch?v=VtqmRkyyvCw)

3. Shared Benefits

3.1 Aboriginal Cultural Values and Uses of Waterways

Maximising cultural benefits and Aboriginal community outcomes from managing water in the environment in the lower Wimmera River (RMCG, 2020) reviewed environmental water actions like the watering of Ranch Billabong as well as other initiatives such as the *River Yarns* Aboriginal Waterway Assessments of the lower Wimmera River. It documented the positive outcomes associated with these actions as well as providing recommendations to enhance them further, such as including clearer links to objectives related to cultural benefits and Aboriginal community outcomes as well as improved monitoring, evaluation and reporting to show if and how these objectives are being achieved. Wimmera CMA is currently working with Barengi Gadjin Land Council (BGLC) to implement these recommendations and in 2021 BGLC undertook some preliminary site visits to refuge pool sites on the MacKenzie River and Burnt Creek to scope the cultural heritage values of these sites.

The Ranch Billabong near Dimboola continues to be an example of being able to enhance aboriginal cultural and environmental values (Table 4). The site is managed by BGLC on behalf of the Wotjobaluk people and listed as a significant place in their Country Plan, *Growing What is Good* (BGLC, 2017) which represents the views of a wide cross-section of the Wotjobaluk Traditional Owner community. The billabong is currently connected to the Wimmera River channel by a road culvert constructed by Hindmarsh Shire Council (Walker 2017). The culvert is very high up on the riverbank would only be able to receive flows when the Wimmera River is in flood. The Country Plan lists as priority goals restoring a natural flooding regime to the billabong system and restoring indigenous plant and animal habitats, with particularly attention to controlling priority weeds (BGLC, 2017).

Watering events have taken place at the Ranch Billabong in December 2018, March and October 2019, June 2020 and October 2021. The enhancements to the site's condition (improved water quality and vegetation condition) has complemented the aspirations of Traditional Owners to increase the site's amenity and accessibility via the construction of walking tracks and crossings. Their construction in 2021 has enabled it to be more suitable for gatherings and events such as earth oven and bark canoe re-creations, particularly for elders. Environmental watering at The Ranch was held off until October in accordance with BGLC wishes to enable the completion of crossings and other works and coincide with a planned celebration at their conclusion. Unfortunately the event was unable to go ahead given COVID-19 concerns at the time.

It should also be emphasised that the whole waterway system in the Wimmera is important to the Wotjobaluk people, being valued in its entirety with heritage values existing through the environment. Furthermore, Native Title is held along much of the lower Wimmera River, the first successful claim in Victoria, reinforcing the significance of these values.

Case study: Ranch-ing Out

The staff of Barengi Gadjin Land Council have been undertaking a power of work in 2021 to improve the amenity and accessibility for traditional owners going to The Ranch, just outside Dimboola. Weed control of species like Tobacco Nightshade in combination with vegetation improvements assisted by environmental watering since 2018 has substantially increased the visual appeal of The Ranch Billabong. Not only that but an all-abilities track including culvert crossings has been built around the billabong which means that everyone, from infants to elders can enjoy the very special place that is The Ranch. The momentum looks to continue into 2022 with plans to develop interpretative signage at the site showing local bird and fish species.

Table 4. Traditional Owner Values and Uses

River/Wetland	Values/uses/objectives/opportunities	How will this opportunity be considered in environmental watering in 2022-23?
Ranch Billabong	This site is managed by BGLC and the enhanced condition of the billabong will support the site's use for gatherings and other events as well as tie in with other onground works to	There is an explicit priority watering action to supply water to the Ranch Billabong.

River/Wetland	Values/uses/objectives/opportunities	How will this opportunity be considered in environmental watering in 2022-23?
	improve the billabong's accessibility and condition. It will support contemporary cultural events, such as the Wotjobaluk Cultural Festival by improving water quality and amenity at this site during this event Water will support the health of a culturally significant site and some valued species, such as Old Man Weed/Sneezeweed.	
Other waterways	All waterways are important to the Wotjobaluk people with heritage values existing with the environment.	Environmental watering is intended to maintain and improve the condition of the environmental values of these waterways.

3.2 Social, Recreational and Economic Values and Uses of Waterways

The COVID-19 pandemic again impacted the busy calendar of events centred around the Wimmera River in 2021-22 although some events were able to take place, albeit in a modified format. Rowing events like the Dimboola Regatta and Head of the Wimmera River, scheduled for November were cancelled although rowing training and smaller events like informal regattas and come and try days were able to take place. The Peter Taylor Memorial Barefoot Waterki Classic and Night Jump was rescheduled to February 2022, drawing a large crowd and waterskiing was able to take place at Dimboola throughout 2021-22. In the past the event was forecasted to attract 1800 spectators and generate $280,000 for Dimboola (Lawson, 2019). A waterski demonstration event organised by the Natimuk Lake and Dimboola Ski Clubs also took place in the Horsham Weir Pool as part of Australia Day celebrations as it was not able be part of the traditional Kannamaroo Festival activities in late 2021.

There was no Dimboola Fishing Classic in late 2021 given considerations around COVID-19 at the time. However the Horsham and Jeparit Fishing Competitions were able to take place. The Horsham Fishing Competition again showed the way when it comes to adapting to the challenges presented by COVID-19. Instead of fish being taken for weighing by stewards with crowds gathering to see the fish and presentations at the Horsham Soundshell, fish were measured on a 'brag mat' and photos submitted via phone and presentations were announced over local radio.

The Horsham Triathlon continues to be in recess given the committee does not currently have the volunteer capacity to run it (an issue affecting community groups across the region). More positively the Wimmera River Parkrun in Horsham was able to recommence in November in line with COVID-19 restrictions easing. Typically around 50 participants of all ages and abilities enjoy exercise along the Wimmera River on Saturday mornings. It also showcases the river to Parkrun participants from other parts of Australia who participate in the Wimmera River Parkrun when visiting Horsham. The success of the Parkrun and high patronage of walking tracks along the Wimmera River has provided the impetus to expand the distance of tracks upstream Horsham with planning work well underway to construct a circuit track past the upstream extent of the Horsham Weir Pool in Dooen.

The Wimmera River continues to be a focus of enhancements to the Wimmera Southern Mallee's visitor economy, a key priority of the Wimmera Southern Mallee Regional Partnership, co-ordinated by Regional Development Victoria. Horsham Rural City Council is continuing planning and contruction work as part of the City to River project including improved tracks and a water activity playspace. Whilst in Hindmarsh Shire, construction and planning work for the Wimmera River Discovery Trail between Dimboola and Jeparit continues, albeit delayed by COVID-19 restrictions. A visitor node has been completed at Dimboola with public amenities like toilets, shower and bicycle security area. Planning for a similar node is nearly finalised at Jeparit which will be focused on the swimming hole, caravan park and recreation reserve. The trail will start in Dimboola and continue through to Lake Hindmarsh, taking advantage of the large tract of public land that exists along the Wimmera River and involve constructing a bridge crossing at Jeparit.

Street Ryan has continued their work capturing the socio-economic benefits of water in the region's waterways in 2020-21 (Street Ryan, 2021) with surveys first commencing in 2016-17 and capturing a wide range of conditions and circumstances. This set of results captured the full impact of the COVID-19 pandemic's restrictions on recreational water use in the region (the 2019-20 survey was only affected from mid-March to June) and so overall useage was down on previous years. The timing of survey interviews was reduced from January to April which tends to favour some recreational pursuits like swimming over ones like canoeing which may be more popular during cooler months.

Highlights include:

- Out of 251,399 survey participants during 2020-21 using the 27 recreational/environmental water sites across the Wimmera Southern Mallee (-11% on 2019-20 and -25% 2018-19), 79,007 were at the Wimmera River at Horsham (-6% on 2019-20) and 20,513 were at the Wimmera River at Dimboola (-9% on 2019-20). These sites continue to have the highest and third highest number of participants in the region, with the river at Dimboola only 133 visits off being the second highest;
- The value of camping sites on the Wimmera River at Horsham, Dimboola and Jeparit is very high as seen by the increased patronage compared to previous years. Travel restrictions meant that tourists from Melbourne and elsewhere in regional Victoria stayed at these locations in much greater numbers, substantially increasing the expenditure by visitors. Estimated expenditure for locations on the Wimmera River was $1.62 million, an increase of 17% on 2019-20.;
- Overnight visitors to the Wimmera River at Horsham, Dimboola and Jeparit contributed an average of $56, $48 and $24 per night respectively with large increases ($>10) for Dimboola and Horsham. For day visitors these figures were $19, $22 and $12. These figures are fluctuating annually but generally trending upwards, emphasising the economic benefits the enhanced appeal and activation of these sites are having.
- Physical and mental health benefits are estimated to total of just over $2.6 million across the 27 sites, of which the three sites on the Wimmera River at Jeparit, Horsham and Dimboola contributed a large proportion. There was a large decrease in this figure since 2018-19 attributable in part to the impact of reduced visitation due to COVID-19 restrictions but also due to dry conditions affecting some waterbodies such as Lake Lonsdale and Lake Toolondo.
- The Wimmera Southern Mallee faces a number of challenges around entrenched socio-economic disadvantage and these sites are located within the bottom third of disadvantaged 'suburbs' in Victoria. Therefore economic outcomes generated in this part of Victoria will be proportionally more beneficial than for other, more affluent areas.

Case Study: Food and Flows – a winning combination!

More regular flows and a much healthier river continues to provide opportunities for the region's hospitality entrepreneurs – combining delicious food and drink with a wonderful vista. Since late 2020 *As Time Goes By* has provided chartered cruises on the idyllic Wimmera River at Dimboola with the opportunity to enjoy some tasty nibbles and a glass of prosecco as you take in the peaceful scenery. Whilst *Voddy and Vacay* is pop-up cocktail caravan located next to the Wimmera River in Horsham, offering exquisite platters and a fantastic range of cocktails as people take in the view and performances by local musicians. It is only a matter of time until the region has a business open near the river offering its culinary contribution to the world – the Steak Florentine (or Florrie for short).

The Wimmera CMA will continue to actively support community events including the ones listed previously by consulting with local community groups and where possible supporting them with environmental water releases where this aligns with environmental objectives and environmental outcomes are not compromised (Table 3). The benefits for the community along the Wimmera River system since the return of regular flows in 2010 have been enormous through increased recreation opportunities and tourism as well as the sense of

wellbeing that comes through seeing water in a waterway and the life it brings.There was also significant appreciation of the river as a place for recreation during COVID-19 lockdowns when opportunities to exercise and socialise were severely curtailed.

There is also strong alignment with DELWP's Our Catchments, Our Communities program with community values from environmental water being enhanced by improved facilities at Horsham and Dimboola Weir pools (new tracks/shelters/rowing pontoons/fish habitat/erosion control/canoe launches). Other waterways (MacKenzie River, Burnt Creek, Mt William Creek) are valued for angling opportunities albeit not to the same degree as the Wimmera River. Dadswell's Bridge has a walking track featuring the Mt William Creek. Dock Lake is also a renowned bird watching site when it contains water.

Table 5. Social, Recreational and Economic Shared Benefits Associated with Environmental Water in the Wimmera

River/ Wetland	Beneficiary	Values/uses/ objectives/ opportunities	How will this opportunity be considered in environmental watering in 2022-23?
Wimmera River only	Rowers/ Canoers	The Horsham and Dimboola Weir Pools are the locations of rowing clubs and an annual regatta is held at Dimboola. Training events and school trips using canoes are an annual occurrence at these weir pools.	Provision of environmental water to maintain pool levels and water quality for multiple reasons will also assist the maintenance of weir pool water levels. (Year round baseflows/freshes)
	Walkers/ Runners/ Cyclists	Tracks along the Wimmera River at Horsham, Dimboola and Jeparit are very popular and support events like the Wimmera River Parkrun.	Provision of environmental water to maintain pool levels and water quality for multiple reasons will also assist the aesthetics and appeal of these tracks.
	Waterskiiers	The Dimboola Weir Pool has a waterski club that regularly uses the river for recreation and organises annual competitions. Horsham Weir Pool is also used for waterski demonstrations at occasions like the Kannamaroo Fesitival.	Provision of environmental water to maintain pool levels and water quality for multiple reasons will also assist the maintenance of weir pool water levels (including tailoring flows around events that align with environmental outcomes). (Year round baseflows/freshes)
	Visitor Economy	The appeal of the Wimmera River in terms of being a destination for visitors for holidays or events such as fishing competitions is enormous, see Street Ryan (2021).	Provision of environmental water to maintain pool levels and water quality for multiple reasons will support these events (including tailoring flows around events that align with environmental outcomes). (Year round baseflows and freshes)
All waterways (except Ranch Billabong and Dock Lake)	Landholders with Stock and Domestic and/or Irrigation licenses	There are a number of landholders as well as councils along these waterways who extract water for various purposes such as watering gardens/ovals (subject to licence conditions).	Environmental water deliveries help maintain water quality and levels.
	Anglers	The Wimmera River is a highly valued destination for anglers looking to catch native (and exotic) fish species. Other waterways are not as highly valued but still provide opportunities.	Provision of environmental water to maintain fish communities will enhance angling opportunities. (Summer/autumn baseflows and freshes and winter/spring baseflows/freshes)
Dock Lake	Birdwatchers	The lake is renowned for the waterbird response when it contains water although it is has been dry since 2016.	There is a priority watering action for Dock Lake for waterbird outcomes.

4. Flow objectives and recommendations

Environmental Objectives

Long-term environmental objectives that form the basis of this proposal are from the *Wimmera River Environmental Flows Study* (Alluvium, 2013). These objectives where identified by the Wimmera CMA at the time in consultation with the Wimmera CMA's Rivers and Streams Advisory Group. The study outlines the flow components that are required to affect the functions and processes that contribute to the over-arching objectives for nominated environmental assets. The *Wimmera River Environmental Flows Study* superseded the information contained within the *Wimmera Bulk Entitlement Conversion – Environmental Flows Study* (SKM, 2003) that had previously been the guiding document for environmental watering in the region.

This study included revised and more relevant environmental objectives that was endorsed by community advisory group members. It considered new knowledge obtained after drought and floods as well as improved understanding of waterway ecology and post-Wimmera Mallee Pipeline system operations to provide a more rigorous and adaptable set of flow recommendations for different climatic conditions (drought, dry, average and wet) instead of static annual ones.

The environmental objectives and flow components for each asset are summarised in Table 6 and outlined in detail in Appendix 2. They are consistent with the *Wimmera River Environmental Flows Study* (Alluvium 2013). The exception is the upper Mt William Creek, which was not part of the scope of that study and have been drawn from a previous report, *Environmental Recommendations for the Mt William Creek* (SKM 2005). The *Wimmera River System Environmental Water Management Plan* (Wimmera CMA, 2015) outlines in more detail the objectives, recommendations and other matters pertaining to environmental water management (e.g. system operation) in the Wimmera. It will be updated to include improved objectives to link with broader environmental watering documents required under the *Basin Plan*.

Studies providing environmental watering recommendations have also been undertaken for the Wimmera River's terminal lakes system (Jacobs, 2019) and Dock Lake (Jacobs, 2015). These lakes are not normally targeted for regulated environmental water releases but chiefly rely on passing and/or unregulated flows to provide suitable inundation to achieve ecological outcomes. Although regulated releases are of some value for enhancing terminal lake levels and environmental outcomes (Jacobs, 2014). There is no capacity to deliver regulated flows to Yarriambiack Creek though a proportion of flows in the Wimmera River pass into the Yarriambiack Creek. The environmental water requirements of Yarriambiack Creek and its terminal lakes can only be met by unregulated and passing flows.

Hydrological data illustrates that environmental water availability is often less than the water needed to deliver recommended flows. It should also be noted that most of the larger flow components (e.g. bankfull and overbank) cannot be delivered through regulated releases in almost all cases (see Section 8 Constraints). Other factors (e.g. prohibitive channel losses and risks around inundation private land) also make most of these releases unfeasible. Overbank flow recommendations will only be provided by natural events.

Events like summer freshes like this one in the Wimmera River at Vectis in January 2022 engage new habitat and provide additional carbon inputs

Table 6. Environmental objectives and flow recommendations for Wimmera Catchment rivers/creeks (not terminal lakes).

Waterway	Flow Compon-ent	Ecological Value	Environmental Objective	Ecological Objectives	Flow (ML/day)			
					Reach 1	Reach 2	Reach 3	Reach 4
Wimmera River	Baseflow	Macro-invertebrates	Achieve SEPP compliant macroinvertebrate communities	Provide variable flow during low flow season for macroinvertebrates (over woody debris to increase biofilm abundance as a food source). Flush surface sediments from hard substrates for macroinvertebrates. Maintain edge habitats in deep pools and runs, and shallow water habitat availability for macroinvertebrates.	NA	10-100 ML/d		15-30 ML/d
Wimmera River	Baseflow/ fresh	Native fish	Maintain endemic and recreational fish communities and self-sustaining freshwater catfish population	Maintain self-sustaining Freshwater Catfish population in the Wimmera River. Maintain endemic fish communities (provide freshes Oct-Dec to assist spawning/nesting). Restore endemic fish community diversity and abundance by providing flow variability to maintain water quality and a diversity of habitats. Provide adequate water quality/habitat for fish refuge locations in dry periods. Provide native fish passage. Provide increased flow and variability to support fish movement and diversity of habitat.	NA	10-100 ML/d baseflow 35 – 400 ML/d ML fresh		15-30 ML/d baseflow 70 – 200 ML/d fresh
Wimmera River	Baseflow/ fresh	Vegetation	Maintain healthy and diverse mosaics of water-dependent vegetation	Maintain submerged and emergent aquatic vegetation quality, diversity and extent for fish habitat. Maintain near permanent inundated stream channel for riparian vegetation and to prevent excessive in stream terrestrial growth. Prevent terrestrialisation of the lower banks from invasive *phragmites*.	NA	10-100 ML/d baseflow 35 – 400 ML/d ML fresh		15-30 ML/d baseflow 70 – 200 ML/d fresh
MacKenzie River	Baseflow/ freshes	Platypus	Maintain platypus populations	Sustain a platypus population and facilitate its dispersal into the Wimmera River. Provide flow variability to maintain diversity of habitat.	2-27 ML/d baseflow 5-130 ML/d fresh		10 ML/d (baseflow) 35-190 ML/d (fresh)	NA
MacKenzie River	Baseflow/ freshes	Vegetation	Maintain healthy and diverse mosaics of water-dependent vegetation	Protect and restore riparian and floodplain EVCs. Maintain edge habitats in deeper pools and runs, and shallow water habitat availability. Maintain submerged and emergent aquatic vegetation quality, diversity and extent for fish habitat. Inundate riparian vegetation to maintain condition and facilitate recruitment.. Maintain permanent inundation of stream channel to prevent excessive in stream terrestrial species growth.	2-27 ML/d baseflow 5-130 ML/d fresh		10 ML/d (baseflow) 35-190 ML/d (fresh)	NA
MacKenzie River	Baseflow/ freshes/ bankfull/ overbank	Macro-invertebrates	Achieve SEPP compliant macroinvertebrate communities	Maintain edge habitats in deeper pools and shallow water habitat availability for macroinvertebrates. Provide variable flow (freshes) during low flow season for macroinvertebrates (over wood debris to increase biofilm abundance as a food source). Flush surface sediments from hard substrates to support macroinvertebrates. Entrain organic debris in the channel to support macroinvertebrates.	2-27 ML/d baseflow 5-130 ML/d fresh, 500-900 ML/d bankfull and overbank		10 ML/d baseflow 35-190 ML/d freshes 500-1,000 ML/d bankfull and overbank flows	NA
MacKenzie River	Bankfull/ overbank	Geomorph-ology	Maintain structural integrity of stream bed and channel and prevent loss of channel capacity	Maintain the structural integrity of the channel. Maintains floodplain geomorphic features.	500-900 ML/d bankfull and overbank flows		500-1,000 ML/d bankfull and overbank flows	NA
MacKenzie River	Baseflow/ freshes	Native fish	Maintain endemic fish communities	Increase the baseflow water depth to provide stimulus for fish movement. Provide flow variability to maintain water quality and diversity of fish habitats.	2-27 ML/d baseflow 5-130 ML/d fresh		10 ML/d baseflow 35-190 ML/d fresh	NA
Burnt Creek	Baseflow /freshes/ bankfull/ overbank	Vegetation	Maintain healthy and diverse mosaics of water-dependent vegetation	Inundate riparian vegetation to maintain condition and facilitate recruitment. Maintain edge habitats and shallow water habitats and inundated stream channel for riparian vegetation and prevents excessive instream terrestrial growth.	Upper		Lower	
					1 ML baseflow, 30-160 ML/d fresh 400 bankfull 1,000ML/d overbank		45 ML/d bankfull 90 ML/d overbank	
Burnt Creek	Baseflow /freshes/ bankfull/ overbank	Macroinverteb rates	Achieve SEPP compliant macroinvertebrate communities	Entrain organic debris in the channel to support macroinvertebrates. Maintain edge habitats and shallow water habitat availability for fish and macroinvertebrates. Also flushes surface sediments from hard substrates for macroinvertebrates. Disturb the algae/bacteria/organic biofilm present on rock or wood debris to support macroinvertebrate communities.	1 ML baseflow, 30-160 ML/d fresh 400 bankfull 1,000ML/d overbank		45 ML/d bankfull 90 ML/d overbank	
Burnt Creek	Baseflow/ freshes	Native fish and water quality	Maintain endemic fish communities	Maintain edge habitats and shallow water habitats and shallow water habitat availability for fish. Provide variable flow for fish movement and diversity of habitat.	1 ML baseflow, 30-160 ML/d fresh		NA	
Burnt Creek	Bankfull/ overbank	Geomorphic	Maintain structural integrity of stream bed and channel and prevent loss of channel capacity	Maintain structural integrity of channel. Maintains floodplain geomorphic features.	400 bankfull 1,000ML/d overbank		45 ML/d bankfull, 90 ML/d overbank	
Mt William Creek	Baseflow/ freshes/ bankfull/ overbank	Geomorphic	Maintain structural integrity of stream bed and channel and prevent loss of channel capacity	Maintain structural integrity of channel. Maintains floodplain geomorphic features.	Upper		Lower	
					>500 ML/d bankfull/overbank		750/d ML/d bankfull 1,500 ML/d overbank	
Mt William Creek	Baseflow/ freshes/ bankfull/ overbank	Vegetation	Maintain healthy and diverse mosaics of water-dependent vegetation	Maintain edge habitats and shallow water habitat availability for near-permanent inundated stream channel for riparian vegetation and prevents excessive instream terrestrial species growth. Inundate riparian and floodplain vegetation to maintain condition and facilitate recruitment.	>500 ML/d bankfull/overbank		5 ML/d baseflow 20-500 ML/d freshes 750 ML/d bankfull 1,500 ML/d overbank	
Mt William Creek	Baseflow/ freshes/ bankfull/ overbank	Native fish and water quality	Maintain endemic fish communities	Provide variable flow during low flow season for fish movement and to maintain water quality and diversity of habitat. Prevent water quality decline by flushing pools during low flows. Wet low and highest benches, entraining organic debris and promoting diversity of habitat.	>24 ML/d baseflow, >1 ML/d - > 52 ML/d fresh		5 ML/d baseflow 20-500 ML/d freshes 750 ML/d bankfull 1,500 ML/d overbank	
Mt William Creek	Baseflow/ freshes/ bankfull/ overbank	Macroinverteb rates	Achieve SEPP compliant macroinvertebrate communities	Maintain edge habitats and shallow water habitat availability for macroinvertebrates. Provide variable flow during low flow season for macroinvertebrates (over wood debris to increase biofilm abundance as a food source). Flush surface sediments from hard substrates to support macroinvertebrates.	>24 ML/d baseflow, >1 ML/d - > 52 ML/d fresh		5 ML/d baseflow 20-500 ML/d freshes 750 ML/d bankfull 1,500 ML/d overbank	
Bungalally Creek	Bankfull/ overbank	Vegetation	Maintain healthy and diverse mosaics of water-dependent vegetation	Protect and restore riparian and floodplain EVCs. Inundate riparian vegetation to maintain condition and facilitate recruitment.	60 ML/d bankfull 150 ML/d overbank			
Bungalally Creek	Bankfull/ overbank	Geomorphic	Maintain structural integrity of stream bed and channel and prevent loss of channel capacity	Maintains the floodplain geomorphic features and the structural integrity of the channel	60 ML/d bankfull 150 ML/d overbank			

5. Seasonal review

5.1 Climatic conditions this year and seasonal outlook

Conditions in 2021-22 continued the series of very dry years experienced since 2016 although it was by no means the driest of years in that series. After heavy rainfall events in summer (that also generated blackwater events), conditions were slightly better than usual coming in to winter with instream pools and farm dams being slightly fuller. Conditions started off in promising fashion with very good rainfall in from May through to mid-August, particularly in the upper catchment. However, a very dry end to August and below average rain in September saw flows drop away once again just as the catchments were primed to generate high volumes of runoff. However the good start to winter saw the most continuous unregulated flows from the upper catchment since 2016, going for 6 months (the end of June to the end of December). Figure 2 illustrates the cumulative rainfall deficits of four consecutive very dry winter/spring periods and the importance of managing environmental water resources through undertaking restrained watering actions given the low allocations that have resulted. Conditions in 2022 have started off warm and dry despite the La Niña weather pattern, which again has tended to generate heavy rainfall in eastern, northern and central Victoria but not in the Wimmera. Therefore heavy rainfall will again be required in autumn and winter to generate runoff into waterways.

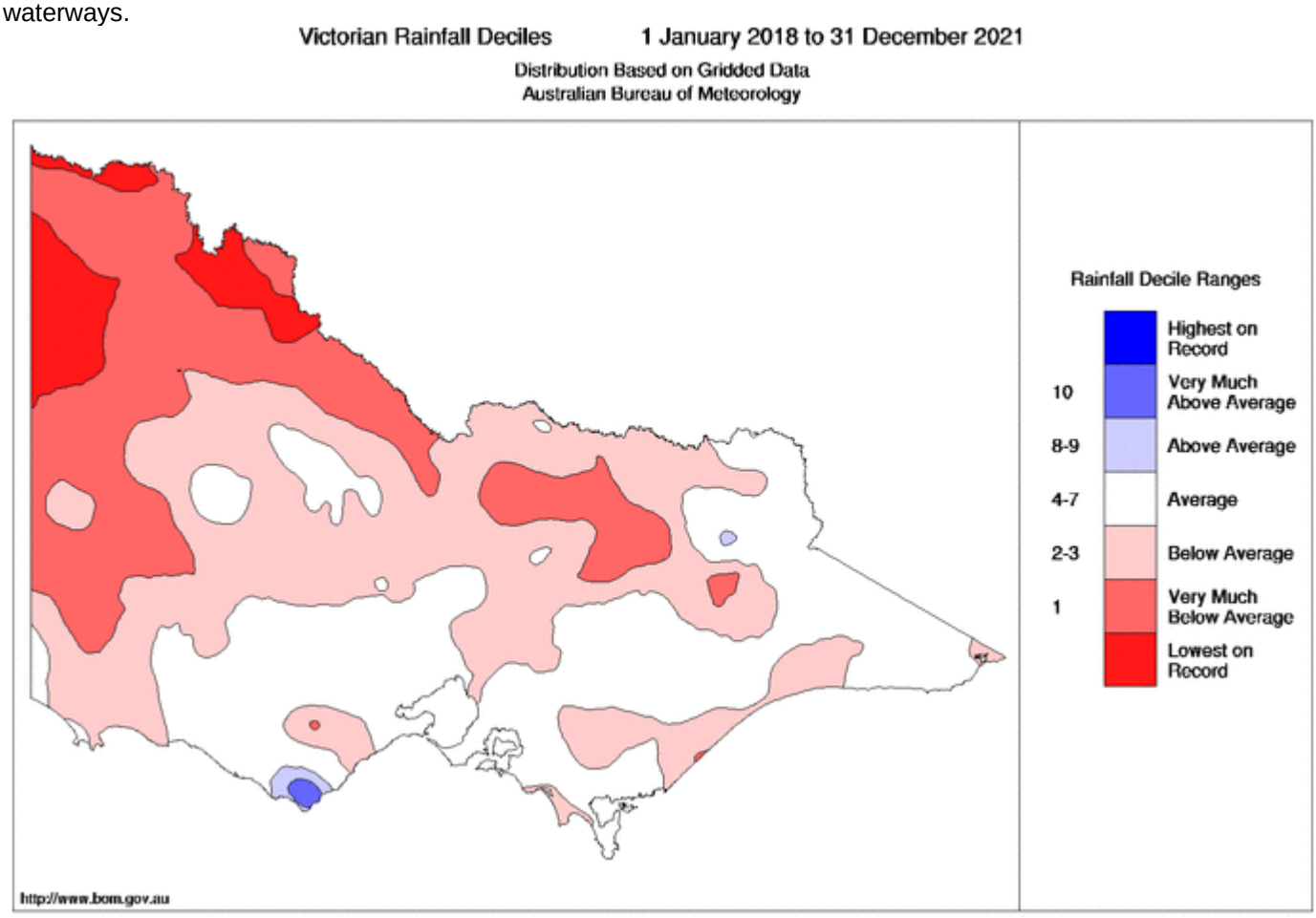


Figure 2. Bureau of Meteorology rainfall deficiencies from 1 January 2018 to 31 December 2021 http://www.bom.gov.au/jsp/awap/rain/archive.jsp?colour=colour&map=decile&year=2021&month=2&period=48month&area=vc).

Since 2019-20, summers have been mild to average which lessened evaporation losses and reduced temperature-induced stresses on aquatic biota. Inflows to all storages were again very low across the storages with gains

outweighed by losses/usage (

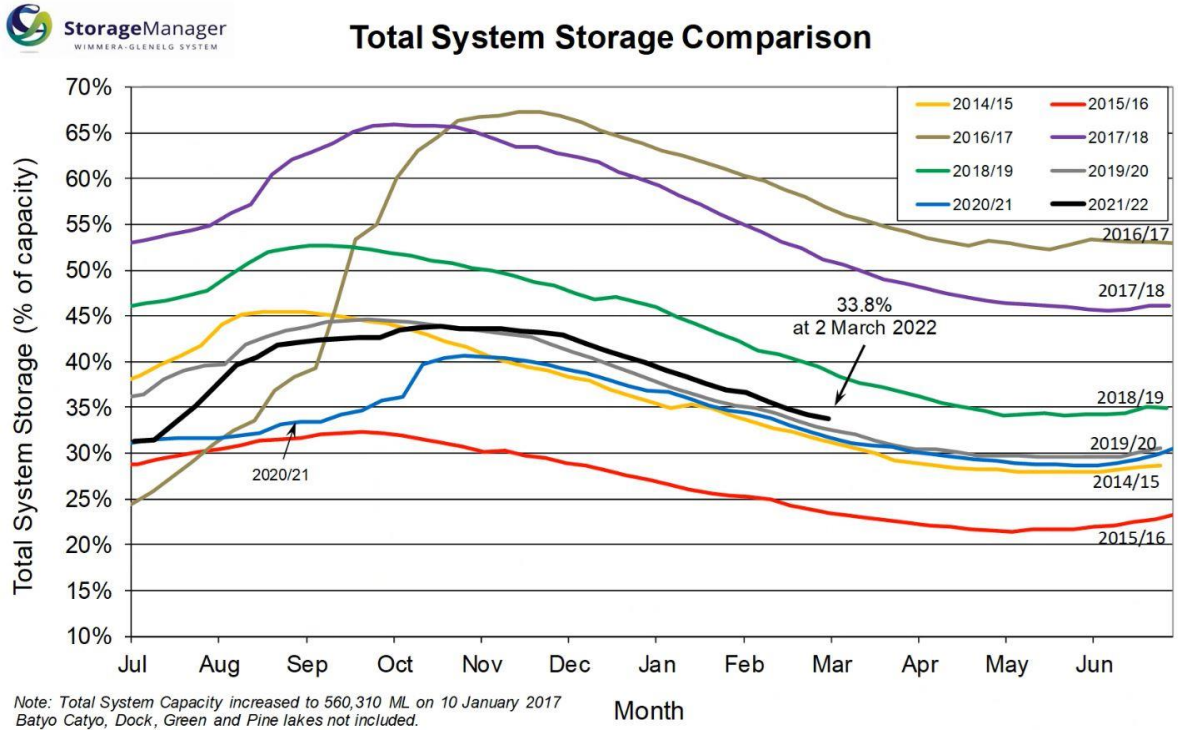


Figure 3). Inflows to storages to the end of January 2022 totalled 73,340 ML, tracking a fraction lower than the 90% probability of exceedance. This comes on the back of a series of years with inflows rangingbetween about 45,000 to 70,000 ML in comparison to 2016-17's 244,600 ML. Therefore, as of March 2022, allocations for high reliability entitlements (VEWH product for Wimmera/Glenelg Rivers) were at 57% whilst CEWH allocations remained at 0% with no prospect of any allocations in the coming months.

As illustrated in Figure 2, there was a modest spatial discrepancy in rainfall across the catchment with rainfall totals in the east being higher than average (e.g. Ben Nevis) whilst in the west they were lower (e.g. Kanagulk). The discrepancies' impact on flows across the system and comparisons with 2016 (a wet year with about 30% probability of exceedance) and 2017-2021 (very dry years with 80-95% probability of exceedance) are shown in Table 7. Although MacKenzie River at Wartook is mostly regulated by Lake Wartook upstream, there have been flows due to upstream pickup and releases to meet target levels at Lake Wartook. Since 2017 most flows along the MacKenzie River have been due to releases for environmental watering and Horsham's water supply.

Table 7. Annual streamflows from 2016-2021 at gauges in unregulated reaches (Mt William Creek and Wimmera River) and regulated reach (MacKenzie River)

Location	Yearly Flow (ML)					
	2016	2017	2018	2019	2020	2021
Mt William Creek at Mokepilly	35,022	3,614	264	11,472	2,416	7,773
Wimmera River at Glenorchy	116,737	3,824	0	11,708	4,347	25,625
MacKenzie River at Wartook	19,572	13,003	8,956	5,752	5,987	5,741

Passing flows in 2021/22 were volumetrically modest given the dry conditions, however importantly, the passing flows from Huddleston's Weir were very continuous, providing regular winter and spring baseflows and freshes that connected the length of the Wimmera River. Some passing flows accumulated at Lake Lonsdale were released in February to refill refuge pools on the Mt William Creek and reduced reliance on regulated releases in 2021/22 to provide a number of priority watering actions although evaporative losses and water quality concerns are limiting the volumes delivered to the creek. Reasonable rainfall totals in the Grampians meant water levels in Lake Wartook rose to heights not seen since 2017. It also resulted in the first year without annual drought contingency planning for the storage since 2018 with no forecast shortfalls for environmental and consumptive demands. However watering actions have been largely focussed on continued drought refuge management given the balancing of water use from Lake Wartook compared to other priorities.

Table 8. Passing flows for 2016/17-2021/22 for Mt William Creek at Lake Lonsdale and Wimmera River at

Huddleston's Weir (*2021/22 figure to February)

Location	Passing Flows (ML)					
	2016/17	2017/18	2018/19	2019/20	2020/21	2021/22
Mt William Creek at Lake Lonsdale	3,321	2,078	335	690	369	2,729
Wimmera River at Huddleston's Weir	51,064	1,750	0	262	2,310	1,946

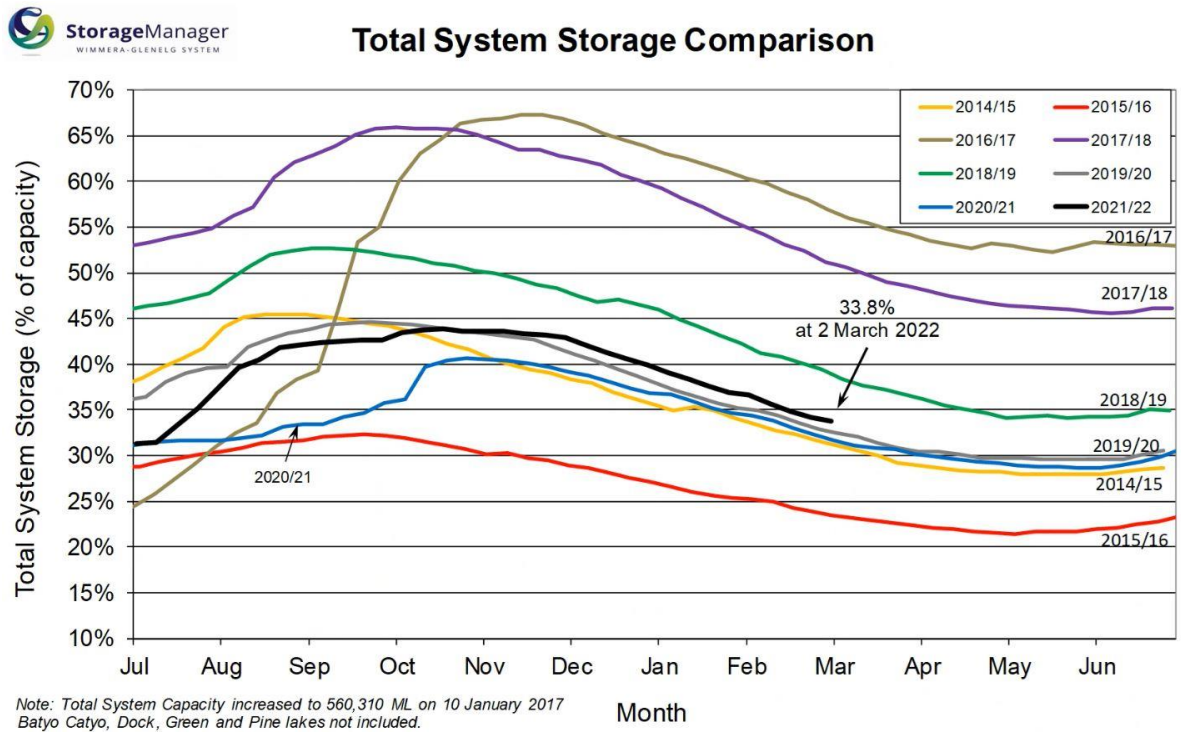


Figure 3. GWMWater storage volume comparison to start of March 2022 (GWMWater 2022).

Despite summer 2021-22 being flagged as a La Niña year leading widespread wet conditions in South Australia, New South Wales and northern Victoria, the Wimmera remained dry unlike summer 2021 which was noted two very heavy rain events that led to flows in the Wimmera River. The warm, dry weather led to increased evaporative losses (particularly on the MacKenzie River) and temperature-stresses on biota in waterways. Similar to recent years, significant rainfall in autumn and winter 2022 will be required to fill pools/dams and generate streamflows given warm, dry weather since January has again dried out catchments across the region. With a shortfall in system operating water for 2022-23 present as of March, allocations are likely to be 0% or very low at the start of the water year and this will also affect passing flows (should they take place) through restrictions as prescribed in the Environmental Entitlement.

5.2 Review of 2020-21 watering with respect to shared benefits outcomes

Section 3 discusses the various outcomes with respect to shared benefits and how they were affected by the COVID-19 pandemic. They are summarised in Table 9.

Table 9. Shared benefits outcomes associated with environmental watering in 2021-22

Beneficiary	Noted benefits/outcomes from 2021-22 watering
Traditional Owners	Enhancements to the water quality, birdlife and vegetation associated with watering at Ranch Billabong which is very important site for traditional owners.
Rowers/Canoers	Regular opportunities to train on the Horsham and Dimboola Weir Pools for regattas as well as come and try days and informal regattas were provided by a combination of environmental water and unregulated flows that maintained water levels. The Dimboola Regatta and Head of the Wimmera were again cancelled due to COVID-19. Training sessions to obtain accreditation as a canoe guide were held in Horsham Weir Pool by Canoeing Victoria.
Waterskiiers	Regular opportunities to waterski on the Dimboola Weir Pool were provided by a combination of environmental water and unregulated flows that maintained water levels. The Peter Taylor Barefoot Classic event took place in February and Dimboola and Natimuk Ski Club Australia Day demonstration with weir pool heights temporarily supplemented by regulated releases which were subsequently released downstream to provide freshes.
Anglers	Anecdotal reports continue to come in that the Wimmera River is fishing the best it has for many years. Fish populations benefited from carbon inputs generated by blackwater events and the carbon-rich water was dispersed downstream by environmental water releases and unregulated flows.

Visitor Economy	Despite periodic COVID-19 impacts to regional tourism and local visitation, some events like the Horsham Fishing Competition were still able to go ahead. Caravan parks adjacent to the Wimmera River at Horsham, Dimboola and Jeparit received strong visitor numbers when conditions permitted.
Water extractors	Environmental water provided opportunities for stock and domestic and garden/oval watering through enhanced water quality and water levels (helping priming of pumps).

5.3 Review of 2021-22 watering, ecological observations and monitoring

The Wimmera system's regulated environmental water usage in 2021-22 is planned to be up to 12,800 ML from 27 September to 30 June based on the volume authorised by VEWH (Seasonal Watering Statement #3). No water was available from the CEWH entitlement. This water was authorised to provide a proportion of baseflows and freshes for several waterways. Some unregulated flows and water transfers meant that regulated releases were not required for some watering actions and there are opportunities to conserve volumes for subsequent years given the current modest resource situation. Results are summarised for various waterways in Table 10. Planning through to the end of June (as of March 2022) indicates that approximately 11,000 ML of regulated water will be used – 1,800 ML less than the maximum volume authorised for use in the region.

Table 10. Summary of the environmental water delivered compared to what was authorised and required to achieve compliance of priority watering actions (PWA).

Waterway	Estimated water required to achieve Tier 1a PWA compliance under scenario (ML)		Planned to be Delivered by 31st March (ML)
	Extreme Drought	Average	
Wimmera River	7,500	13,000	4,760
MacKenzie River	1,400	3,230	1,375
Burnt Creek	800	750	
Mt William Creek	150	900	220*
Bungalally Creek		300	0
Total	**9,850**	**18,180**	**6,450**

*passing flows accrued in Lake Lonsdale and not regulated releases

5.3.1 Wimmera River summary

With ongoing limited water environmental water availability coming into 2021-22 and regular unregulated and passing flows through winter/spring 2021, regulated releases Wimmera River did not commence until January. Above average rainfall from May to June created a wetted catchment that generated streamflows reaching Glenorchy in late June. Whilst August was comparatively dry, spring was generally slightly wetter than average in the upper catchment so unregulated and regulated flows continued through to December, negating the need to provide regulated releases. A notable event was a very heavy rainfall event in early November where up to 60 mm of rain fell over 24 hours in the upper catchment, particularly around Navarre, on the north-eastern edge. This generated a strong flow pulse (300-400 ML/d over several days at Glenorchy) which was noted to trigger a breeding response from Golden and Silver Perch. Large numbers of these fish (including gravid females) were visible immediately downstream of Horsham Weir exhibiting spawning behaviour. Monitoring is underway to try and ascertain the success of the recruitment event with the concept being that it could change the current widespread view that these species are not able to be self-sustaining in the Wimmera due to infrequent recruitment events.

The high carbon levels from the January blackwater event (the highest flows since the 2016 floods, Table 11) plus the ongoing natural flows have provided a shot in the arm to the river's fish population. Anglers are frequently remarking just how many fish they are catching as well as their size and condition, particularly for Golden Perch and Freshwater Catfish although Silver Perch and Redfin are also benefiting from the improved conditions. Regulated releases will be important over the rest of 2021-22 for maintaining suitable habitat in pools through diluting saline groundwater intrusions and ensuring water levels are high enough to engage fringing vegetation and woody debris. A recent review by water quality expert, Dr Darren Baldwin into the blackwater event in January 2021 showed that environmental water released from Taylors Lake at the time were pivotal for the avoidance of a fish death through providing a source of highly oxygenated water (Rivers and Wetlands , 2022). Local observations also noted the flows re-seeded waterbodies like the Horsham Weir Pool with phytoplankton, providing an additional source of oxygen after phytoplankton levels dropped in the immediate aftermath of the high flows flushing them through the system.

Table 11. Mean peak daily flows for the Wimmera River at Glenorchy (415201)

Year	Month	Peak Mean Daily Flow (ML/d)
2016	September	22,978

Year	Month	Peak Mean Daily Flow (ML/d)
2017	August	410
2018	N/A	0
2019	August	904
2020	October	634
2021	January	3447

Unfortunately streamflow gauging at Horsham (415200) has been limited due to problems with the control structure and the apparent need for the river to dry out for an extended period for the repair works to take place. Therefore the quality of flow data through 2021-22 is poor, at low flows in particular.

Table 12. Summary of Priority Watering Actions (PWA) delivered for Reach 4 of the Wimmera River 2020/21 (Wimmera River at Lochiel, 415246).

PWA delivered for reach 4 Wimmera River	Flow magnitude/ duration/ frequency	Comment
Winter/Spring baseflow	30 ML/d	Mostly achieved with natural flows (August-November)
Summer/Autumn baseflow	15 ML/d	Partial achievement of this with a combination of natural and managed flows (limitations due to low allocations and high losses)
Summer/Autumn freshes	70 ML/d 2-7 days x 3	One achieved by natural flows (December) and one with regulated releases (February) with one more planned with managed flows (May)
Winter/Spring freshes	70 ML/d 5 days x 4	Two achieved due to natural flows (August and November). Potential for one in June 2022.
Winter/Spring freshes	200 ML/d 3 days x 3	Two achieved due to natural flows (August and November).
Winter/Spring freshes	1,300 ML/d 3 days x 2	Natural flows provided one in August. (Not regulated water objective unless unregulated component is large given capacity constraints)
Anytime bankfull	2,000 ML/d 2 days x 1	Unregulated flows insufficient to provide component. (Not regulated water objective). August flows peaked at about 1,500 ML/d for 2 days.
Winter/Spring overbank	6,000 ML/d 1 day x 1	Unregulated flows insufficient to provide component. (Not regulated water objective)

Risks to ecological and physical objectives for the Wimmera River Reaches 3 and 4 are included in Table 13 and Table 14 below. The results highlight for Reach 3 environmental and passing flows have been important for reducing risks to the various objectives. Higher risks are attributed to higher flow events that need significant unregulated and passing flows for their attainment (>400 ML/d) rather than being able to be delivered through regulated releases due to capacity constraints. Risk levels have also reduced steadily for Reach 4 due to the reasons described above. The only flow component that is keeping risk levels elevated is summer/autumn freshes although they are planned to be achieved this water year (post-completion of seasonal watering proposal) as two of the three required freshes have already been completed.

Table 13. Risk indices for Fish (blue), Macroinvertebrates (yellow), Vegetation (green), Geomorphology (grey) and Water Quality (pink) for Reach 3 of the Wimmera River.

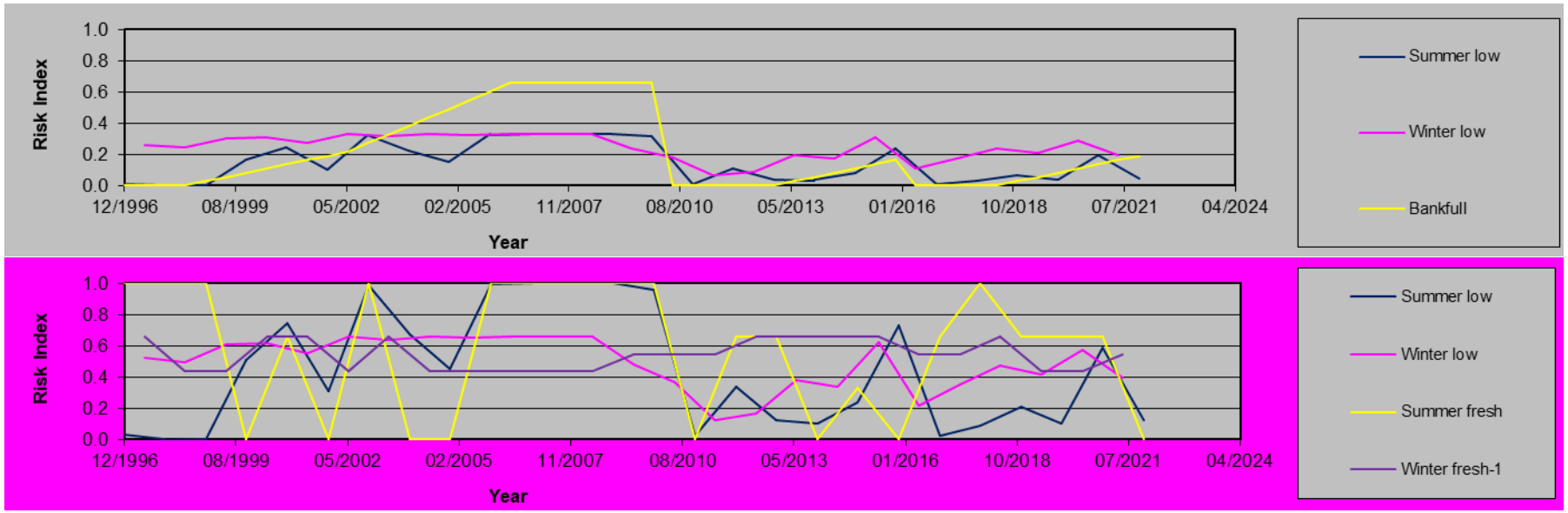
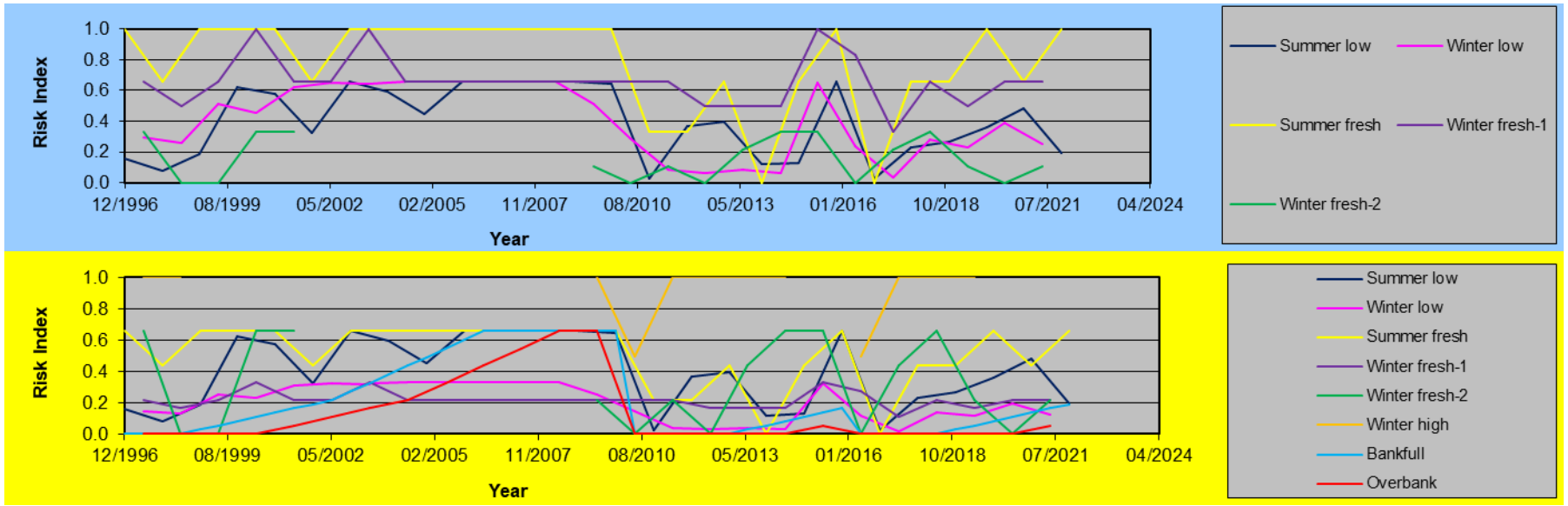
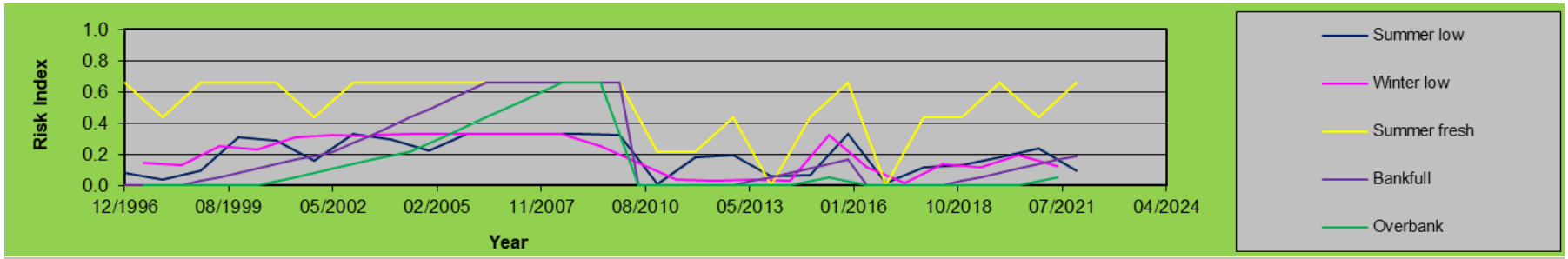
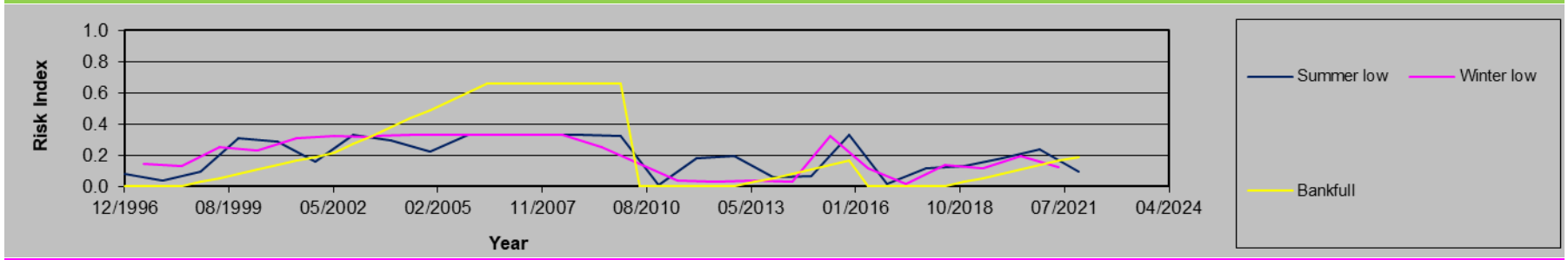
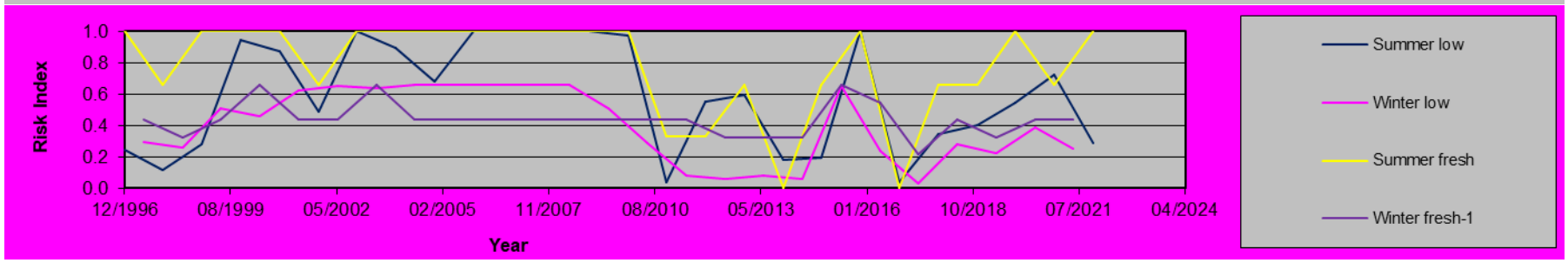


Table 14. Risk indices for Fish (blue), Macroinvertebrates (yellow), Vegetation (green), Geomorphology (grey) and Water Quality (pink) for Reach 4 of the Wimmera River.




Risk Index
1.0
0.8
0.6
0.4
0.2
0.0
12/1996
08/1999
05/2002
02/2005
11/2007
08/2010
05/2013
01/2016
10/2018
07/2021
04/2024
Year
Summer low
Winter low
Summer fresh
Bankfull
Overbank


Risk Index
1.0
0.8
0.6
0.4
0.2
0.0
12/1996
08/1999
05/2002
02/2005
11/2007
08/2010
05/2013
01/2016
10/2018
07/2021
04/2024
Year
Summer low
Winter low
Bankfull


Risk Index
1.0
0.8
0.6
0.4
0.2
0.0
12/1996
08/1999
05/2002
02/2005
11/2007
08/2010
05/2013
01/2016
10/2018
07/2021
04/2024
Year
Summer low
Winter low
Summer fresh
Winter fresh-1

Wimmera River Angler Report Card Fish Surveys

The fifth round of fish surveys for the angler report card were again undertaken in May 2021 by staff Austral Research and Consulting at eight sites along the Wimmera River from upstream of Horsham (Longerenong) to Jeparit using a combination of fyke nets and electrofishing. Whilst the focus was on angling species of interest (Golden Perch and Freshwater Catfish), there were observations of Flathead Gudgeon, Common Galaxias and Australian Smelt as well as Carp, Goldfish, Eastern Gambusia and Redfin. A total of five Freshwater Catfish were caught across Horsham Weir Pool, lower Norton and Horseshoe Bend near Dimboola. Due to their physiological characteristics, they have never appeared in large numbers in fish surveys and numbers have been consistently low with only one caught in 2021, four in 2019 and two in 2017 and 2018. Golden Perch numbers were back up from 2020 (21) with 35 caught compared with 38 caught in 2019, 41 in 2018 and 11 caught in 2017. Three Silver Perch were caught compared to none in 2020 and with 10 collected in 2019 and two and three trapped in 2018 and 2017 respectively. It is planned to undertake another round of surveys in autumn 2022. It is notable that there are consistently high numbers of Redfin caught in these surveys (e.g. 46 in 2020 and 62 in 2021) indicating the river is remains highly productive although they will be impacting on numbers of small-bodied native fish.

Wimmera Carp Monitoring Program

Austral Research and Consulting recommended the continuation of carp monitoring as part of a suite of integrated actions as part of the *Wimmera Carp Management Plan 2020* (Austral, 2020). So whilst no dedicated carp removal work took place in 2021, a number of sites had carp removed as part of the native fish report card monitoring. Since 2016 carp recruitment has been limited given the dry conditions, however results in 2021 demonstrated some carp recruitment particularly in Horsham Weir Pool and downstream of Jeparit Weir (
Table **15** and Figure 4 – note the cohort of fish with fork lengths < 200mm). Survival and growth rates of juvenile carp may have been enhanced by the substantial natural flows generated by the heavy rainfall in January 2021.

Table 15. Carp numbers caught as part of the Wimmera Carp Monitoring Program 2016-19 and Angler Report Card monitoring. Sites labelled [c] are control sites. Sites in black are riverine sites and in red are weir pool sites. Sites are listed in most upstream to most downstream by group.

	Oct 16	Dec 16	Jan 17	April 17	June 17	June 18	Feb 19	May 19	May 20	May 21
Lwr Norton [c]					2		34	7	18	25
Quantong	15	15	22	24	9	23				
Polkemmet	15	17	47	7	23					
Lochiel	2	16	26	42	10					
Spears Crossing	0	3	17	12	0		19	19	25	19
Antwerp	0	31	21	61	1	23	99	12		
d/s Jeparit Weir	45	49	70	31	28		18	23	4	43
Bigwater	11	12	26	19	-				13	31
Horsham[c]			46			10	17	10	13	26
Dimboola	7	4	19	10	17	27	24	19		
Jeparit	6	2	13	13	9				17	17

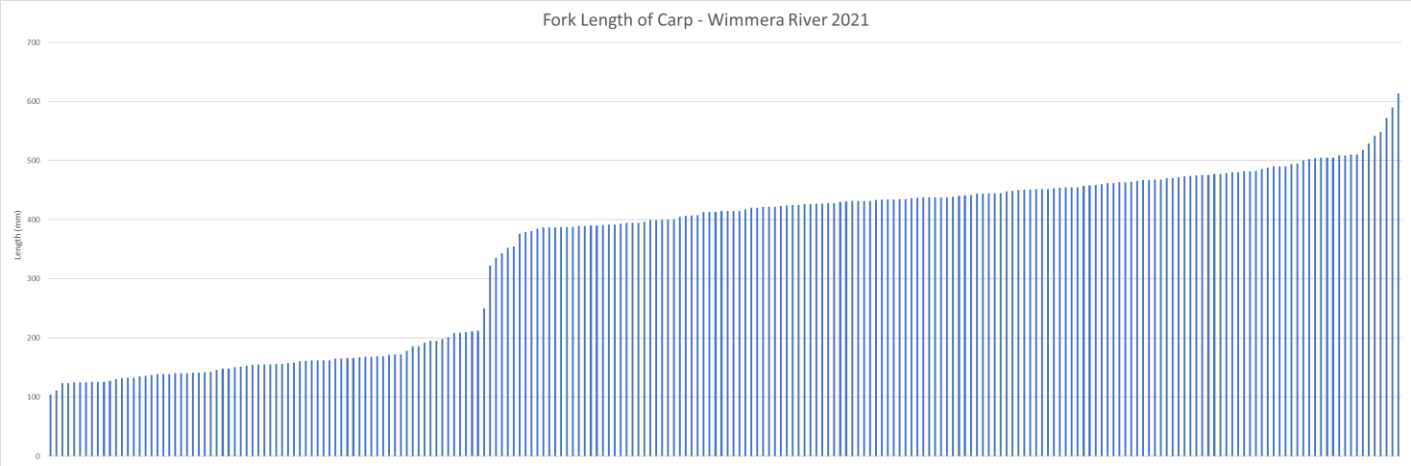


Figure 4. Carp Fork Length from Angler Report Card Survey Work (Austral, 2021).

Fishing Competition Results

Unfortunately during 2021 fishing competitions continued to be affected by uncertainty and restrictions associated COVID-19 although 2022 is seeing a positive turnaround with increased participation. In 2021, the Dimboola Fishing Classic was cancelled and entrant numbers were down for the Horsham (capped at 1000 entrants) and Jeparit Fishing Competitions. The Horsham Fishing Competition changed from determining the prize winning fish based on weight to length given it reduced issues around the lack of social distancing at the weigh-in location and reduced the stress on fish caught during the competition and trends in fish numbers are shown below (Figure 5). The results for Jeparit's 2021 Easter Fishing Competition were more muted than in previous years with only 16 Golden Perch and 8 Freshwater Catfish caught. Previous years have seen typically two to three times the number of these fish weighed in at the competition.

In 2021 native fish captures almost reached the highest number since 2017 and the numbers of entrants would have been about 50% fewer in 2021 compared to 2017, indicating a greater catch per unit effort. With the competition transitioning to being judged by length and not weight, statistics around weights were not able to be obtained. A notable statistic was the number of Freshwater Catfish caught (45) which is more than double the next highest number caught since 2014 (21 in 2020). Anecdotal reports from the 2022 competition are that carp numbers were unfortunately much higher but there were still a lot of native fish caught and they remain in excellent condition.

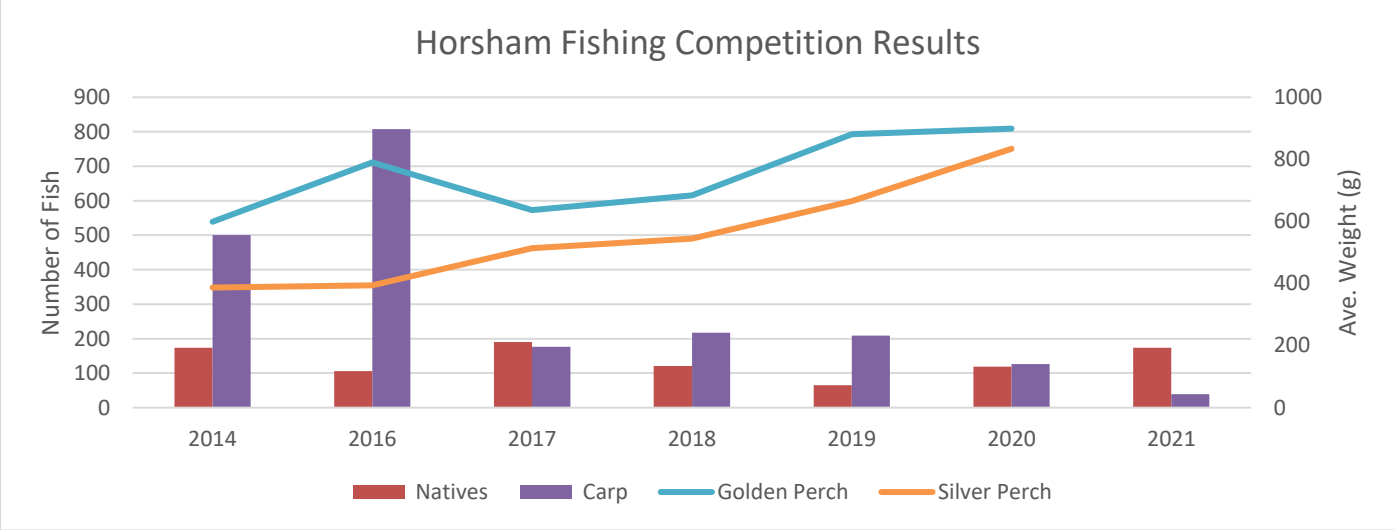


Figure 5. Native fish and carp capture numbers and average weight of stocked native fish species at the Horsham Fishing Competition

5.3.2 Ranch Billabong summary

The supply of another 6 ML to Ranch Billabong took place in October 2021 through pumping water from the Wimmera River led further improvements in salinity levels (Figure 6) which in turn stimulates local improvements birdlife and wetland vegetation at the site (particularly canopy condition). eDNA monitoring took place at the site in late 2021 which contained genetic material from Pacific Black Ducks, Australian Wood Ducks and Brushtail Possums. Unfortunately the only fish DNA in the billabong came from Redfin and Carp. A bird survey was also undertaken in 2021 by Murnong Ecological Services, with 28 species identified including Diamond Firetails (a threatened species) which demonstrates the broader ecological benefits associated with the billabong's improving condition due to on-ground works by BGLC complemented by environmental watering. Prior to these works stressed riparian vegetation, poor water quality and high weed coverage provided little suitable habitat. There is also increasing abundance of wetland plant species, particularly rushes and the appearance of water in the billabong continues to improve (Figure 7).

Table 16. Bird species surveyed at Ranch Billabong, 2021.

Australian Magpie	Eastern Rosella	Peaceful Dove	White-plumed Honeyeater
Australian Owlet-nightjar	Galah	Purple-crowned Lorikeet	Willie Wagtail
Australian Reed-warbler	Grey Shrike-thrush	Rainbow Lorikeet	Whistling Kite
Common Bronzewing	Grey Teal	Red Wattlebird	Noisy Miner
Common Starling	Laughing Kookaburra	Red-rumped Parrot	Dusky Moorhen
Crested Pigeon	Long-billed Corella	Southern Boobook	
Diamond Firetail	Masked Lapwing	Sulphur-crested Cockatoo	

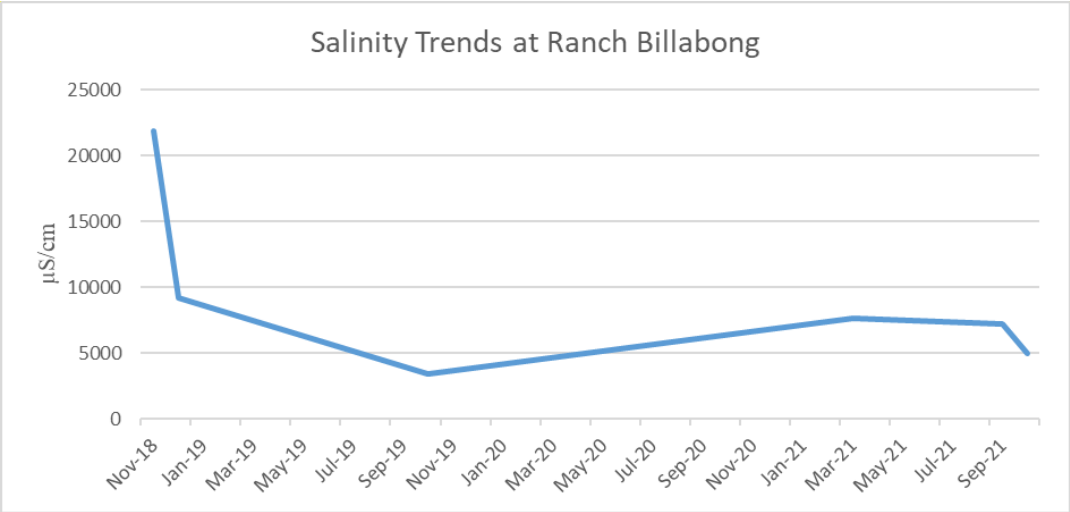


Figure 6. Salinity levels in Ranch Billabong

Figure 7. Ranch Billabong December 2018 (left) and October 2021 (right).

5.3.3 MacKenzie River summary

Conditions were wet enough in 2021 to see Lake Wartook reach its highest levels since spring 2017 (when it reached full supply level). This means that for the first time since 2018, there has not been a need to undertake drought contingency planning for consumptive and environmental water supplies from the storage. Despite the lake experiencing comparatively higher water levels, it only reached 80% of full supply level in November before beginning to decline in response to warm, dry weather. So the combination of the need to consider water availability in future years should conditions remain dry as well as modest overall environmental allocations meant that water deliveries have not substantially changed since 2018, with a focus remaining on drought refuge management.

Unregulated flows took place along Reach 2 for most of winter and spring thanks to consistent rainfall events although it was by no means a ‘wet’ year for this system compared to historic conditions. In June and August unregulated flows were large enough to have a portion directed into Reach 3 at Distribution Heads instead of Burnt Creek. Issues with overbank flows affecting freehold land due to small channel capacities on parts of Burnt Creek means that flows over a certain volume are directed into Reach 3 of the MacKenzie River. In spring and summer, small environmental flows from Moora Moora Reservoir and Lake Wartook periodically watered most of Reach 3 to maintain water in refuge pools from Laharum to McKenzie Creek (Figure 8). Given the state of Lake Wartook’s water levels, high losses incurred during summer deliveries and an understanding of the river’s current environmental values, it was decided to maintain the drought refuge management approach developed in early 2019. Although the frequency of top ups was able to be slightly increased to reduce stress on biota in the most downstream refuge pools which were experiencing declines after several years of very infrequent flows. After spilling in 2017, experience gained from 2018 – 2020 shows that Lake Wartook has very little by way of buffering low flow conditions (Figure 10) and there are significant consumptive demands on the storage (i.e. Horsham, Natimuk and Supply System 6 of the Wimmera Mallee Pipeline).

The refuge pools in the lower MacKenzie River remained at suitable levels through winter and early spring due to the low evaporative losses, rain on the pools and periodic unregulated flows. As conditions became warmer and drier in October, releases commenced from Distribution Heads (sourced from the Moora Channel) to top up the pools.

Unregulated flows from local runoff and transfers to deliver water from Distribution Heads were sufficient to maintain conditions in the mid-MacKenzie River through to mid-November when releases took place to target refuge pools in the lower MacKenzie River and Burnt Creek.

There are three priority refuge pools in the lower MacKenzie River, the two upstream pools are comparatively close to Distribution Heads and have been targeted for more regular environmental watering (Figure 9) . The most downstream one (at the McKenzie Creek Reserve Gauge) (Table 17) requires a lot more water to reach so only receives occasional top ups every few months with a flow in December 2021, intended to maintain aquatic and fringing vegetation being the last occasion. The aquatic and fringing vegetation continues to increase in condition and abundance. Environmental watering in spring and early summer sees these plants able to complete recruitment events and disperse seed downstream. This is particularly important for the MacKenzie River given the impacts of motorbike riding along the base of the channel during drought years has impacted the remnant seed bed of aquatic vegetation (C. Jones, ARI, *pers. comm.*)

From an operational perspective, flows for the MacKenzie River from Dad and Dave were again combined with periodic transfers for the Brimpaen Storages to share losses given the high instream losses noted in this reach now, presumably due to a sand slug washing in to the river at Wartook from Chinaman's Creek following the 2014 bushfires and 2016 floods.

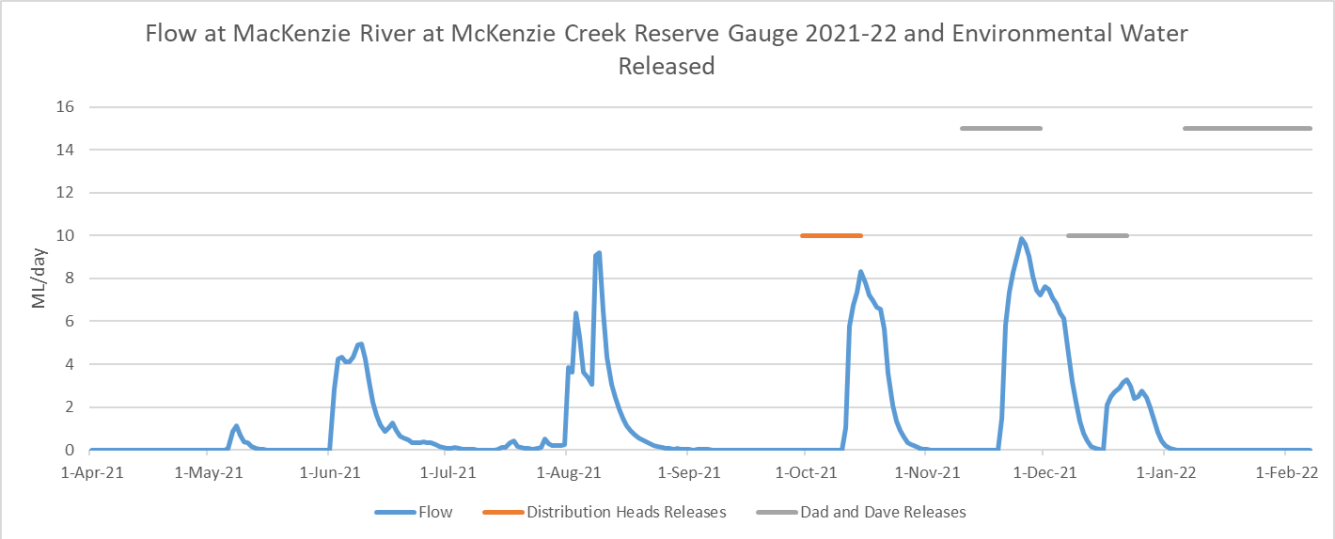


Figure 8. Flow summary for Reach 3 of MacKenzie River at McKenzie Creek Reserve stream gauge (415451).

'Big' Kev the platypus, caught in the good paddock of the MacKenzie River, April 2021

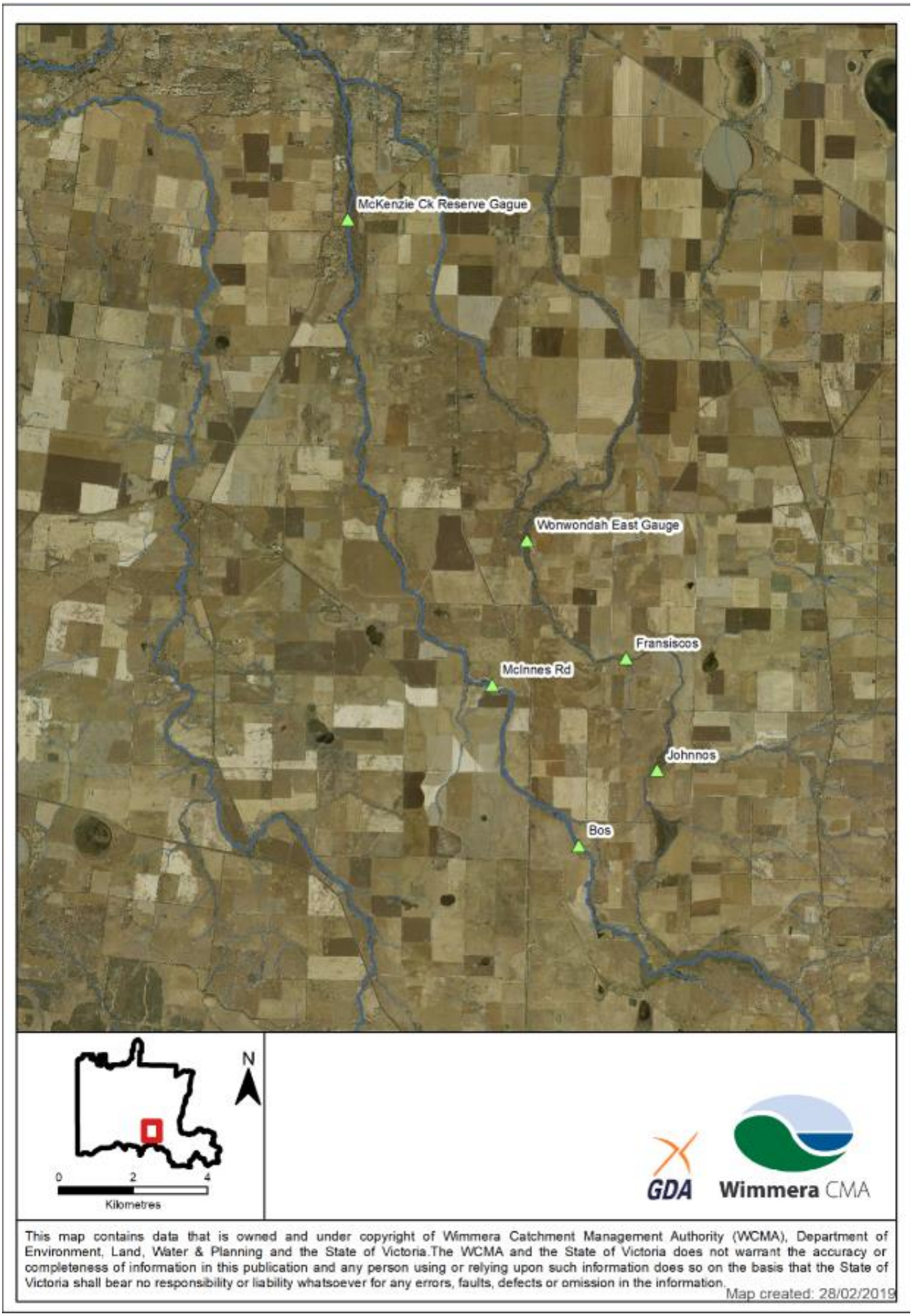


Figure 9. Refuge Pool locations on the lower MacKenzie River and Burnt Creek.

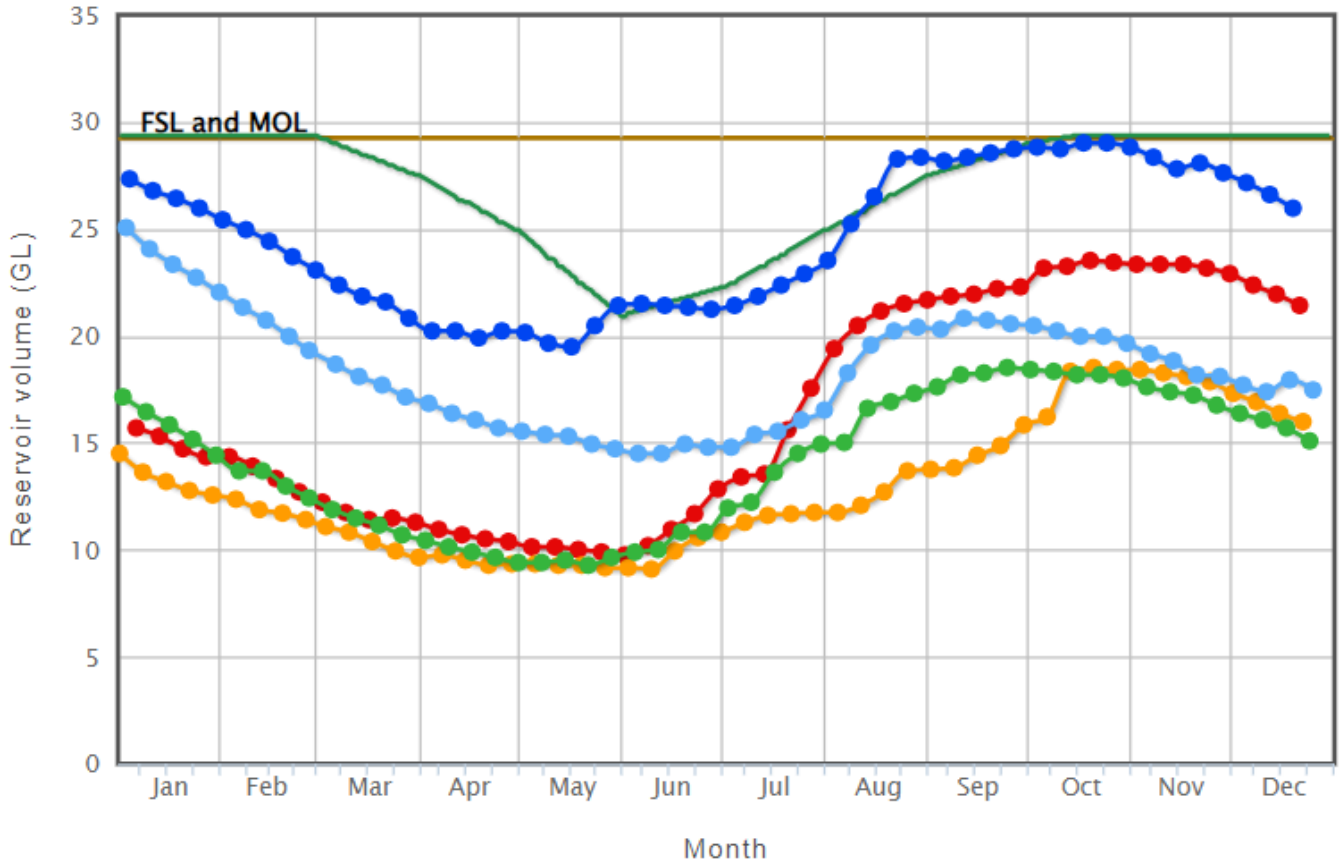


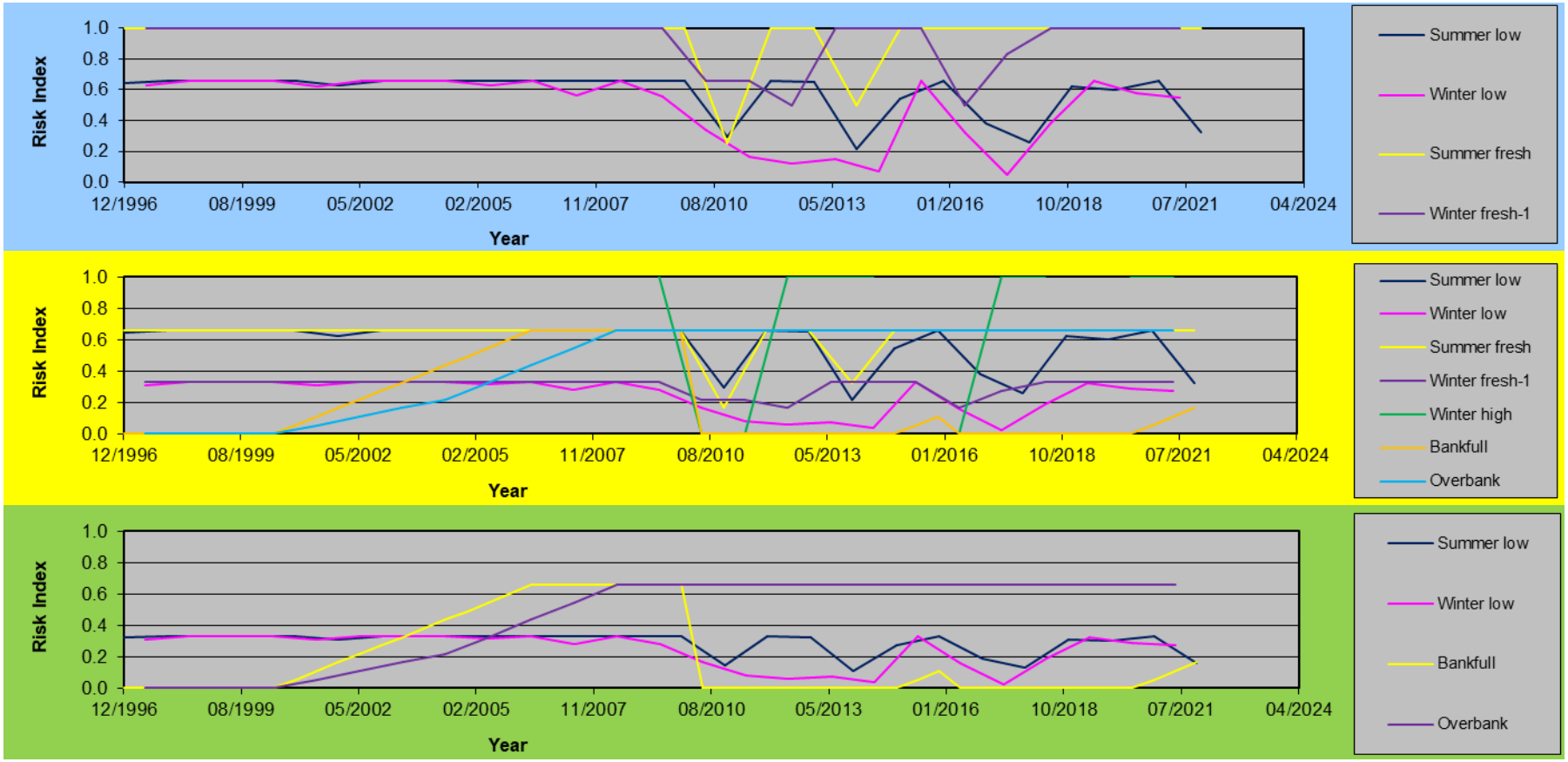
Figure 10. Storage levels for Lake Wartook for 2017 (dark blue), 2018 (light blue), 2019 (green), 2020 (orange) and 2021 (red). Source: storagemanager.com.au FSL – Full Supply Level, MOL – Maximum Operating Level

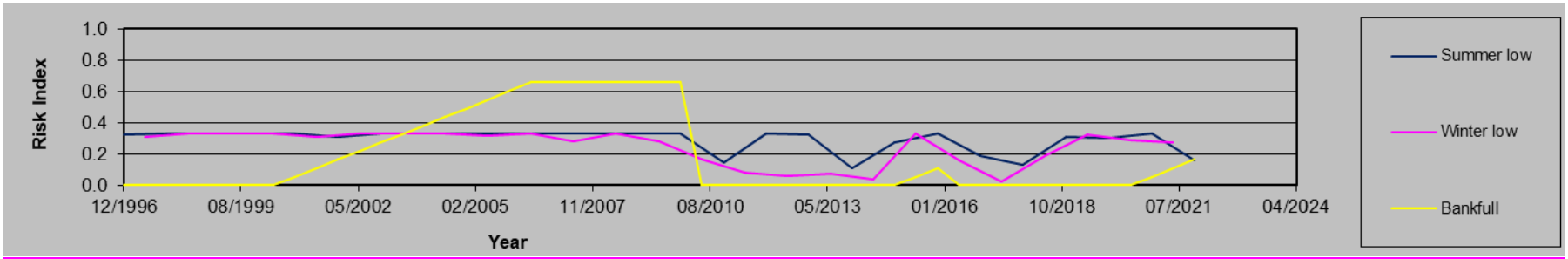
Table 17. Summary of Priority Watering Actions (PWA) delivered for Reach 3 of the MacKenzie River.

PWA delivered for Reach 3 MacKenzie River	Flow magnitude/ duration/ frequency	Comment
Baseflows	10 ML/d or natural	Dry conditions have largely prevented this with almost no unregulated flows and limited volumes in Lake Wartook/Moora Reservoir.
Summer/Autumn freshes	35 ML/d 2-7 days x 3 - 4	Not currently an objective given the low levels in Lake Wartook and preference is to conserve volumes for flows in future years.
Winter/Spring freshes	35 ML/d 2-7 days x 5	Not an objective given the low levels in Lake Wartook and preference is to conserve volumes for flows in future years.
Winter/Spring freshes	190 ML/d 1-2 days x 1	Unregulated flows insufficient to provide component. (Not regulated water objective unless unregulated component is large given capacity constraints)
Winter/Spring freshes	500 ML/d 1 day x 1	Unregulated flows insufficient to provide component. (Not regulated water objective). Average to wet years only.
Anytime bankfull	1,000 ML/d 1 day x 1	Unregulated flows insufficient to provide component. (Not regulated water objective). Wet years only

Risks to ecological and physical objectives for the MacKenzie River Reach 3 is included in Table 18 below. The high risks that exist for most values are in response to the lack of flows (summer/winter low flows and freshes) that are due to the recent low water availability in Lake Wartook and need to focus on retaining volumes in the lake for refuge pool watering in future years should conditions remain dry.

Table 18. Risk indices for Fish (blue), Macroinvertebrates (yellow), Vegetation (green), Geomorphology (grey) and Water Quality (pink) for MacKenzie River Reach 3.





Attendees at the Platypus, Breakfast and Josh (PB&J) session at Laharum, April 2021 (left) and Josh Griffiths presenting (right)

Platypus Surveys
Platypus monitoring took place in the MacKenzie River in April 2021 with a combination of live-trapping and eDNA sampling techniques used. Live-trapping results were again modest with a single male platypus caught (Kevin) who was previously captured in 2019. eDNA results from the same time indicated platypuses present from just downstream of Dad and Dave Weir up to above MacKenzie Falls (cesar Australia, 2021) as opposed to previous years which showed the presence of platypus DNA through to Distribution Heads.

The monitoring work concluded with a community breakfast held at Laharum called *P,B&J (Platypus, Breakfast and Josh).* Following a tasty barbeque breakfast, attendees were able to experience a welcome to country and smoking ceremony conducted by traditional owners followed by a presentation from renowned platypus expert, Josh Griffiths. Josh outlined the unique characteristics of platypuses and their plight in the Wimmera in the face of loss of habitat from a lack of water and land use practices but also how they are making a small but significant comeback on the MacKenzie River due to environmental watering. The great turnout on a freezing April weekday morning as well as feedback from participants showed the strong community support for platypus protection and recovery in the region. It also provided a rare and valued opportunity to socialise and network as a community amidst the various lockdowns and restrictions experienced as part of the COVID-19 pandemic in 2020-21.

An additional survey took place on the MacKenzie River in February 2022 by staff from Ecology Australia as a training/professional development exercise. This was just a single night of trapping (normally it is two nights), however they were able to catch four platypuses, a record for a single night on the MacKenzie River. Three juveniles (born winter 2021) of which two were females and one male were captured near Zumsteins and one sub-adult male (born winter 2020) was caught upstream of MacKenzie Falls. Whilst trapping took place in two sites downstream of Dad and Dave Weir, no platypuses were trapped there. However the fact that there appears to be annual juvenile recruitment upstream, the provision of downstream habitat will be vital for their survival when they reach maturity and need to move into a new home range. All platypuses were in average to good condition.

Fish Surveys
In April 2021, staff from ARI revisted most of the fish monitoring sites on the MacKenzie River that were part of the Victorian Environmental Flows Monitoring and Assessment Program (VEFMAP) in 2017/18. Three sites were surveyed in each of Reach 2 and four in Reach 3. For the target species (Obscure Galaxias, Western Swamp Crayfish and Southern Pygmy Perch) in Reach 2, the Catch Per Unit Effort (CPUE) for Obscure Galaxias was much greater in 2021 than the previous survey in 2018 (16 cf. 6), unfortunately there was a modest decrease for Southern Pygmy Perch (24 in 2018 and 14 in 2021). No Western Swamp Crayfish were noted in Reach 2. Reach 3 saw the drop off in Obscure Galaxias and Southern Pygmy Perch numbers noted in Ecology Australia (2021) continue with CPUE for both species declining (4 in 2018 and 0.5 in 2021 for Obscure Galaxias and 21 to 16 for Southern Pygmy Perch). This corroborates monitoring in 2020 which showed that the more downstream refuge pools are having their values impacted by multiple years of the current drought flow regime. More positively, the surveys identified six Western Swamp Crayfish in Reach 3, whereas the 2018 survey revealed none.

5.3.4 Burnt Creek summary

Regulated releases were not required during winter/spring due to wet conditions meaning that runoff from the MacKenzie River downstream of Lake Wartook was being transferred via Burnt Creek to Taylors Lake. This was supplemented by additional transfers from Moora Moora Reservoir that continued into December, creating efficiencies where modest environmental flows were able to continue along most of the creek instead of just the upper Burnt Creek. The comparatively wetter conditions in 2021 compared to the years prior to 2016 are demonstrated in Table 19. One flow briefly in mid-October provided the winter/spring fresh (55 ML/d), this is aligned with the recommended frequency and duration under a drought scenario (Figure 11 and Table 20). The relatively dry conditions in spring meant that regulated releases commenced in November from Distribution Heads to maintain refuge habitat in the three refuge pools in the upper Burnt Creek.

Table 19. Flows during winter/spring for the Burnt Creek at Wonwondah East (415223)

Year	2016	2017	2018	2019	2020	2021
Flow (ML)	20833	4767	2110	2819	1860	8064

No attempts were made to use environmental water to provide recommended flows beyond the provision of drought refuges for high value fish and crayfish species based on the recommendations of Ecology Australia (2019). It should be noted that some flows were at such low rates that they seeped through the flow measurement control weir and so would not have been accurately recorded. Releases during February and March were sufficient to enable flows to reach the lower Burnt Creek. This helped reduce the decline of fringing and riparian vegetation in the lower Burnt Creek and maintain its important Western Swamp Crayfish population.

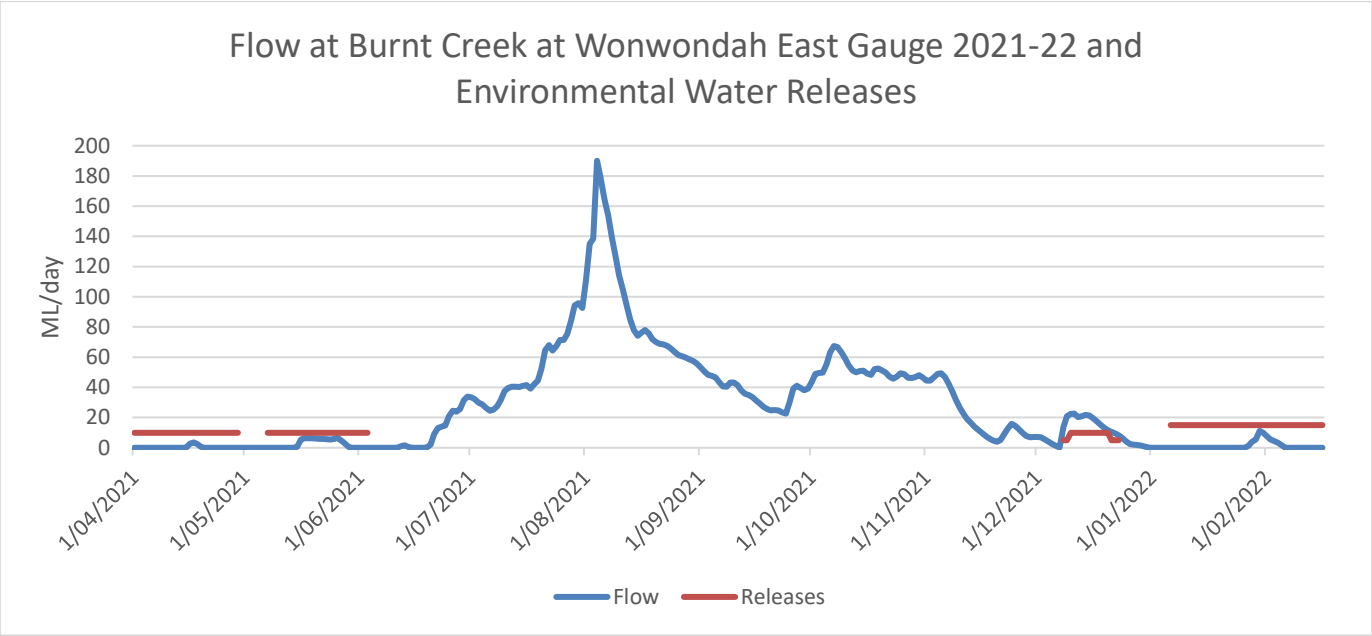


Figure 11. Burnt Creek streamflow at Wonwondah East gauge (415223) and environmental water releases.

Table 20. Summary of Priority Watering Actions (PWA) delivered for upper Burnt Creek recorded at the Wonwondah East gauge (415223).

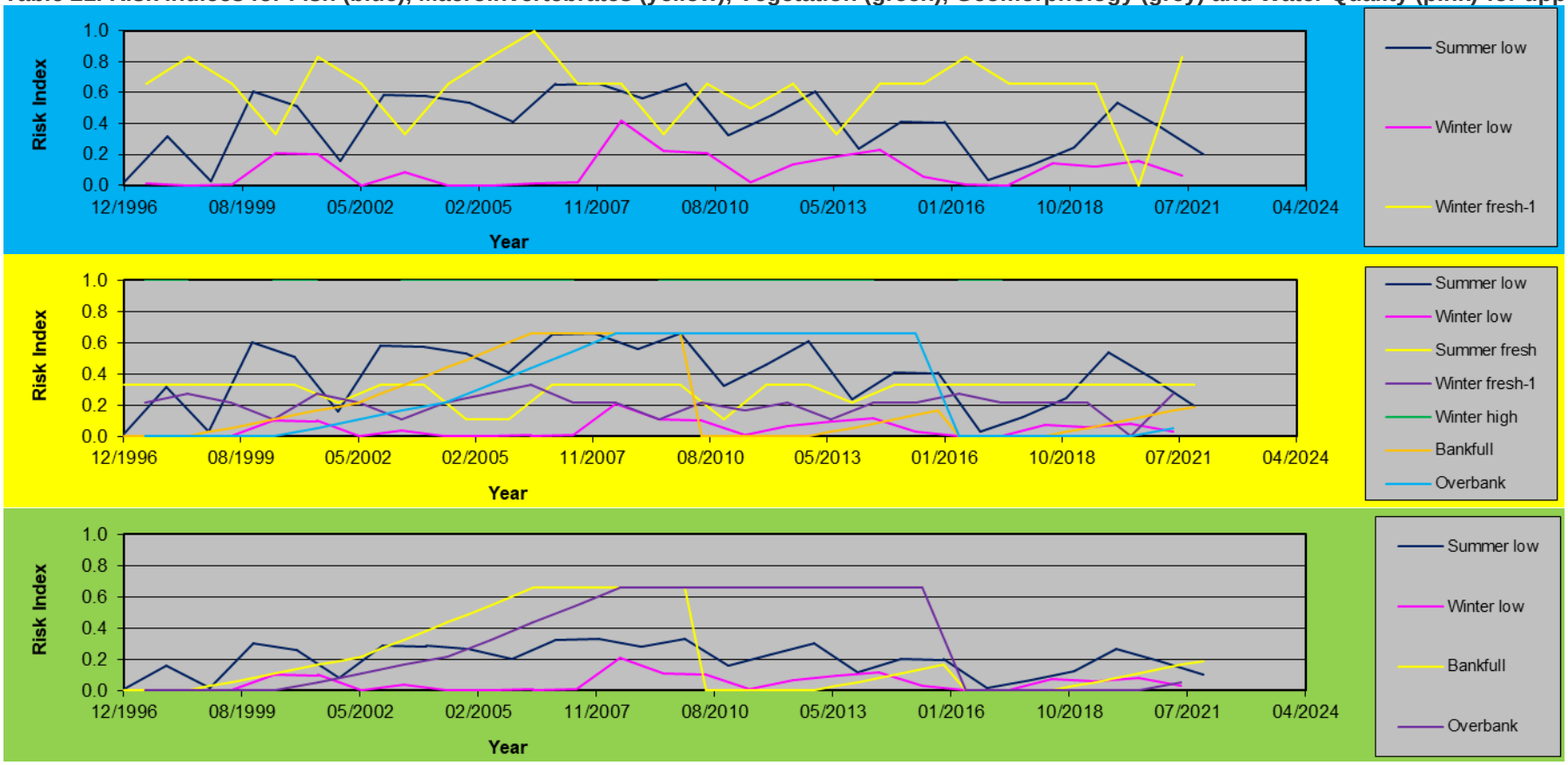
PWA delivered for upper Burnt Creek	Flow magnitude/ duration/ frequency	Comment
Baseflow all year	1 ML/d	Delivered mostly by unregulated flows from June until regulated releases started in December. Cease to flow duration has been greater than recommended due to focus on drought refuge management.
Summer/autumn freshes	30 ML/d 3-7 days x 3	Not an objective this year in summer due to water availability considerations in Lake Wartook although potential for autumn delivery given fewer losses.
Winter/spring freshes	55 ML/d 3-7 days x 1-5	Unregulated flows exceeded this threshold from late July through August, another event achieved with unregulated flows in October
Winter/spring freshes	160 ML/d 1-3 days x 1-3	Achieved by unregaulated flows (Not regulated water objective). Dry-Wet years only.
Any time bankfull	400 ML/d 2 days x 1	Unregulated flows insufficient to provide component. (Not regulated water objective). Average-Wet years only.
Overbank	1,000 ML/d 1 day x 1	Unregulated flows insufficient to provide component. (Not regulated water objective). Wet years only.

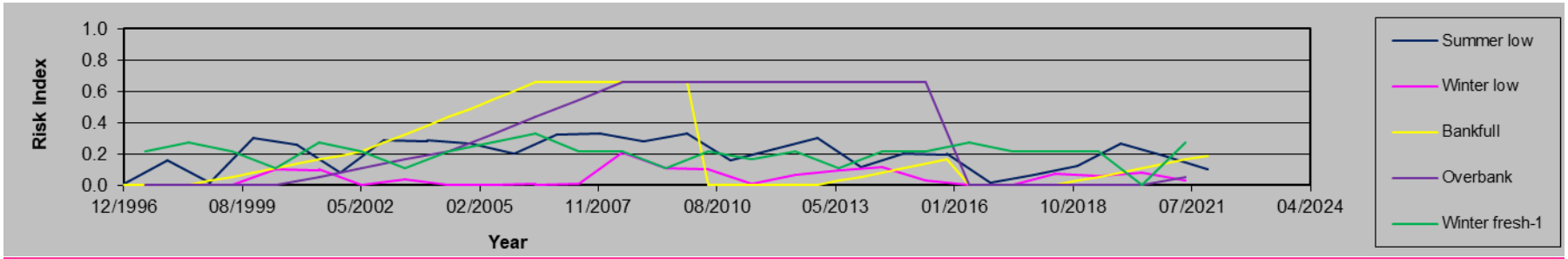
Fish Surveys

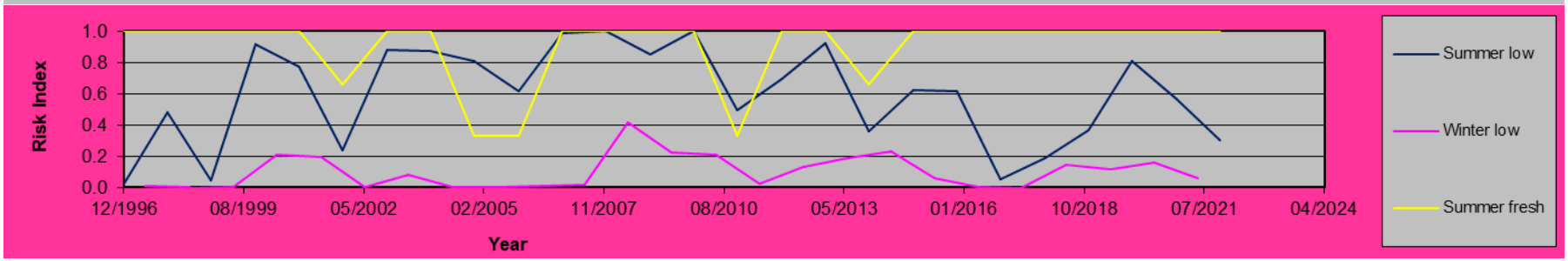
As for the MacKenzie River, in April 2021, staff from ARI revisted most of the fish monitoring sites on the Burnt Creek that were part of VEFMAP in 2017/18. Four sites were surveyed on the Upper Burnt Creek and three on the Lower Burnt Creek. For the target species (Obscure Galaxias, Western Swamp Crayfish and Southern Pygmy Perch) in the Upper Burnt Creek, the trends mirrored those seen in the mid-MacKenzie River as the CPUE for Obscure Galaxias was also much greater in 2021 than the previous survey in 2018 (25 cf. 13), unfortunately there was also modest decrease in the CPUE for Southern Pygmy Perch (24 in 2018 and 14 in 2021). Western Swamp Crayfish were noted in both reaches with the highest numbers noted in the most upstream section of the lower Burnt Creek, the first time they have been captured in this reach. This part of the lower Burnt Creek also retained small numbers of Southern Pygmy Perch and Obscure Galaxias whereas these species were not noted in 2018 after drying out.

Risks to ecological and physical objectives for the Upper Burnt Creek is included in Table 21 below. The results highlight relatively low risk to values in the creek due to a combination of environmental flows, water transfers and unregulated flows. The high risk for fish around winter freshes would be more due to the consistent high flows (i.e. not creating independent fresh events). The drought refuge management approach due to low volumes in Lake Wartook means summer freshes are not being delivered.

Table 21. Risk indices for Fish (blue), Macroinvertebrates (yellow), Vegetation (green), Geomorphology (grey) and Water Quality (pink) for upper Burnt Creek.







Southern Pygmy Perch (left) and Western Swamp Crayfish (right) from April 2021 monitoring on Burnt Creek (Photos: J. Sharley)

5.3.5 Bungalally Creek summary

No regulated environmental flows were delivered to Bungalally Creek in 2021-22, which means its last flow was in June 2018 when Burnt Creek flows reaching the Toolondo Channel were routed to the Bungalally Creek. The creek typically has a very small, shallow channel which does not retain water well, preventing the establishment of enduring fish populations. Given the slightly better water availability situation in Lake Wartook in 2022 compared to the same time in 2021, in autumn there is potential that baseflows reaching the end of upper Burnt Creek to be directed down Bungalally Creek which may reduce the levels of stress on some River Red Gums along the creek. There is no stream flow monitoring currently available on Bungalally Creek.

5.3.6 Mt William Creek summary

Regulated releases were not initially required for lower Mt William Creek given the unregulated flows coming from the creeks flowing from the north-eastern edge of the Grampians (e.g. Briggs Creek, Mud Hut Creek) in winter/spring. Flows also took place along lower Mt William Creek in late spring as GWMWater transferred water from Lake Fyans to Taylors Lake to manage water levels in Lake Fyans prior to infrastructure works in 2022.

The rocky catchment of the northern Grampians means that it is relatively responsive to rainfall events as opposed to the upper Mt William Creek which has a catchment of agricultural land and the eastern edge of the Grampians. Although anectdotally runoff volumes appear to be affected by bushfire regrowth and waterway scouring following floods. The streamflow gauge is located at the very upstream end of this reach, immediately below the reservoir and so flows measured there do not factor in these contributions. However a Portable Automated Logger System (PALS) Unit located downstream at Roses Gap provides water level and salinity data after most tributaries have entered the Mt William Creek. Unfortunately the PALS unit sensors malfunctioned in August 2021 and was unable to be repaired until March with supply chain issues associated with the COVID-19 pandemic. The data available prior to the sensor malfunctions illustrates the impact of the dry conditions in 2020-21 which meant that only limited passing flows (440 ML) were available which meant that once they were delivered in late 2020, most refuge pools dried out. Runoff from local tributaries refilled these pools in late June (Figure 12) and they remained full through to summer due to unregulated flows and water transfers. A small fish death event (a dozen carp) was noted in the creek below Dadswell's Bridge weir in January 2022 due to very low dissolved oxygen levels created by large amounts of organic matter trapped by the weir, very low water levels and warm temperatures.

Hot, dry weather over summer meant that passing flows accrued over winter/spring were released in February to refill the refuge pools. Unfortunately, as per previous years, the poor quality of water in the lake limits the outcomes within the creek with salinity levels of over 4,500 µs/cm (compared to 200-400 µS/cm from unregulated flows in the creek) and extremely high blue green algae counts. However the watering is necessary to avoid the creek drying out completely. Works by GWMWater to remove bars on the downstream gate appears to have avoided previous issues of turtle entrapment although the rockramp has again created issues with fish moving up when flows have been delivered. Fish and yabbies required manual relocation by Wimmera CMA staff once the flows ceased (Table 22) . Wimmera CMA is keen to have GWMWater address this ongoing issue with a long-term engineering solution (e.g. barrier).

Table 22. Fish/Yabbies Removed from Lake Lonsdale Outfall – February 2022

Flathead Gudgeon	Australian Smelt	Redfin	Common Yabby	Common Galaxias	Goldfish/Carp
64	4	8	10	2	2

Figure 13 shows the flows at Lake Lonsdale Tailgauge in response to transfers and passing flows as well as flows at Mokepilly which is unregulated given it is immediately upstream of Lake Lonsdale (see also Table 23). It highlights the continued dry conditions that have affected this part of the catchment which have resulted in Lake Lonsdale remaining at low levels which in turn results in the very poor water quality being a systemic problem in the lake. Post 2016, there has been an annual injection of poor quality water from the upper Mt William Creek from upstream agricultural land and saline groundwater intrusions but very little in the way of dilution into the lake and throughflow downstream which is compounding the issue over time.

Releases are planned to take place in April from Lake Fyans for the upper Mt William Creek given the ongoing dry conditions, with fish monitoring planned in May to determine their effectiveness. Mild weather and heavy rain in summer 2020-21 meant that it was able to receive a small natural flow at the end of January which topped up the refuge pool and so the large beds of water ribbons (*Cycnogeton sp*) have remained inundated, providing good habitat for small-bodied native fish. Monitoring at the pool in March 2020 highlighted the continued decline of priority fish populations with no Southern Pygmy Perch noted there again (like May 2019) and comparatively high numbers of Redfin and Goldfish (it appears that spring 2019 was a very successful breeding event for Goldfish) (**Error! R eference source not found.**). Redfin predation and limited habitat availability during the breeding season (September

– January) due to uncontrolled grazing and fluctuating water levels appear to be affecting Southern Pygmy Perch numbers. Spring surveys have been recommended to provide a better opportunity for understanding total fish abundance and other responses (e.g. recruitment) (Austral, 2020) so there may be an opportunity for this in 2022.

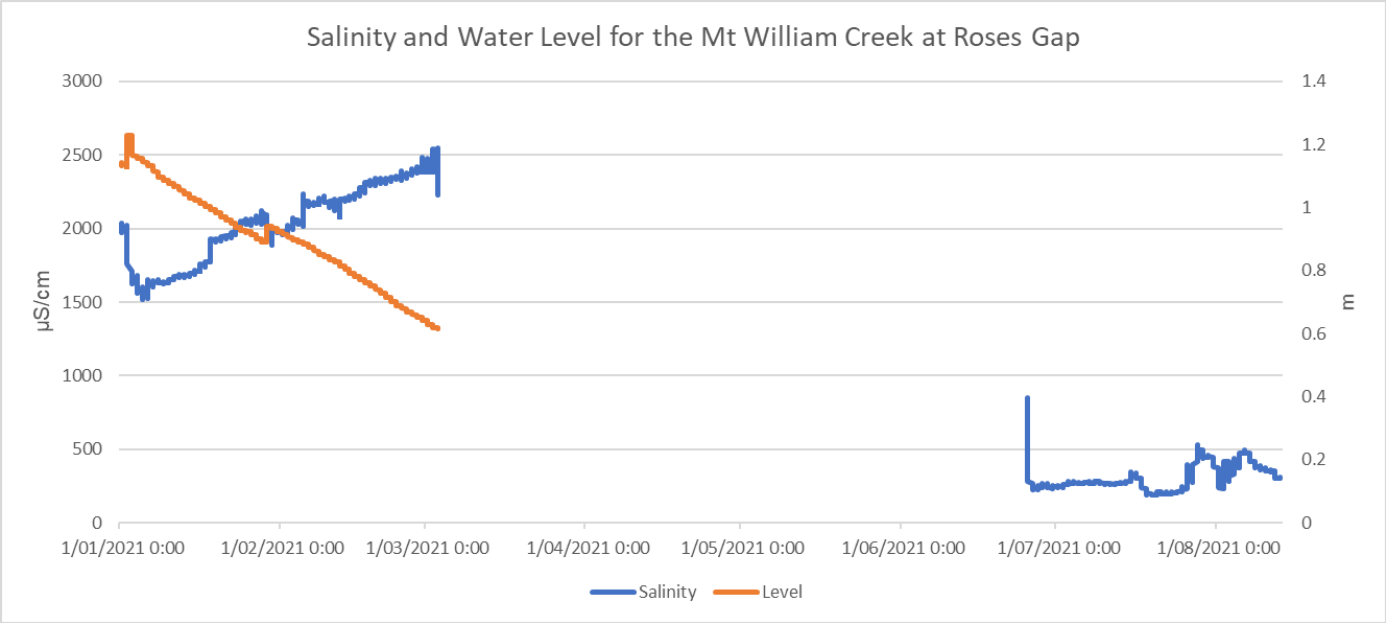


Figure 12. Mt William Creek salinity and level at Roses Gap prior to sensors malfunctioning in March (level) when the pool dried out and August (salinity)

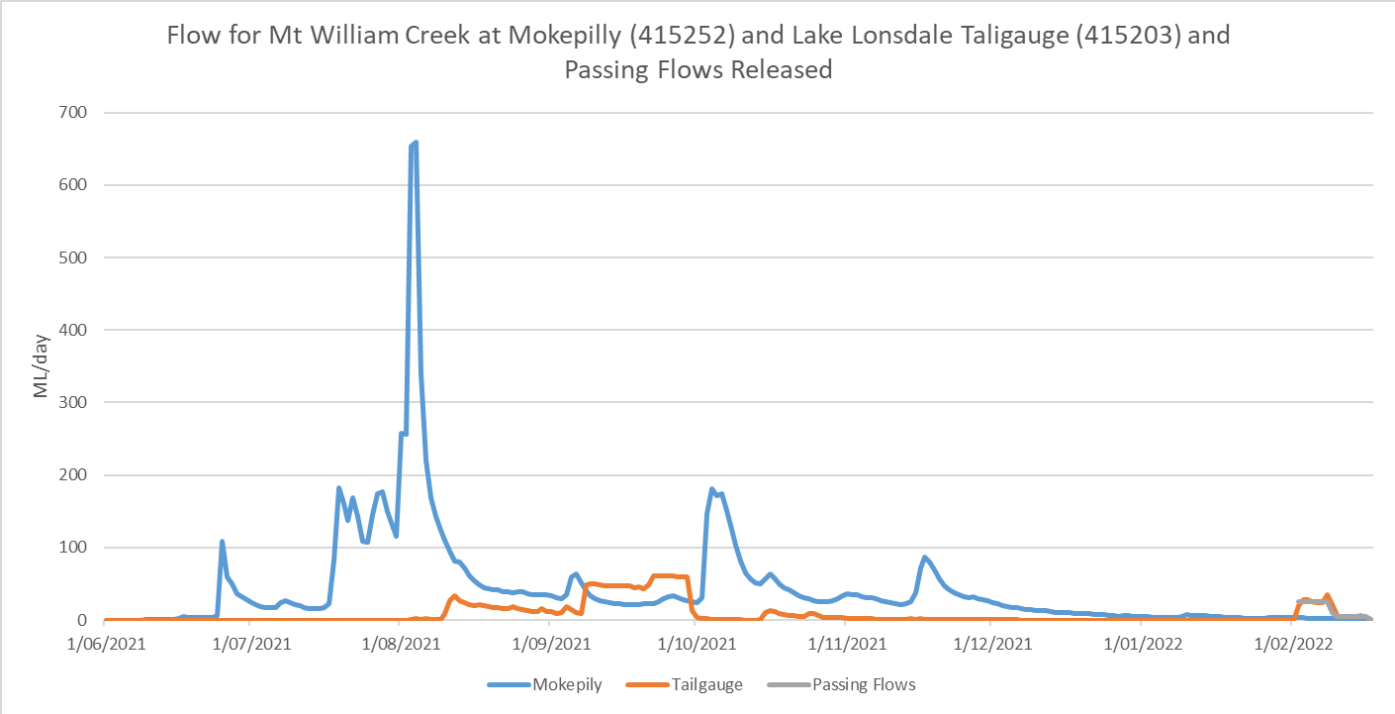


Figure 13. Mt William Creek streamflows (Mokepilly - 415252) and transfers, unregulated, and passing flows (Lake Lonsdale Tailgauge – 415203)

Table 23. Summary of Priority Watering Actions (PWA) delivered for lower Mt William Creek recorded at the Lake Lonsdale Tail gauge (415203) and upper Mt William Creek

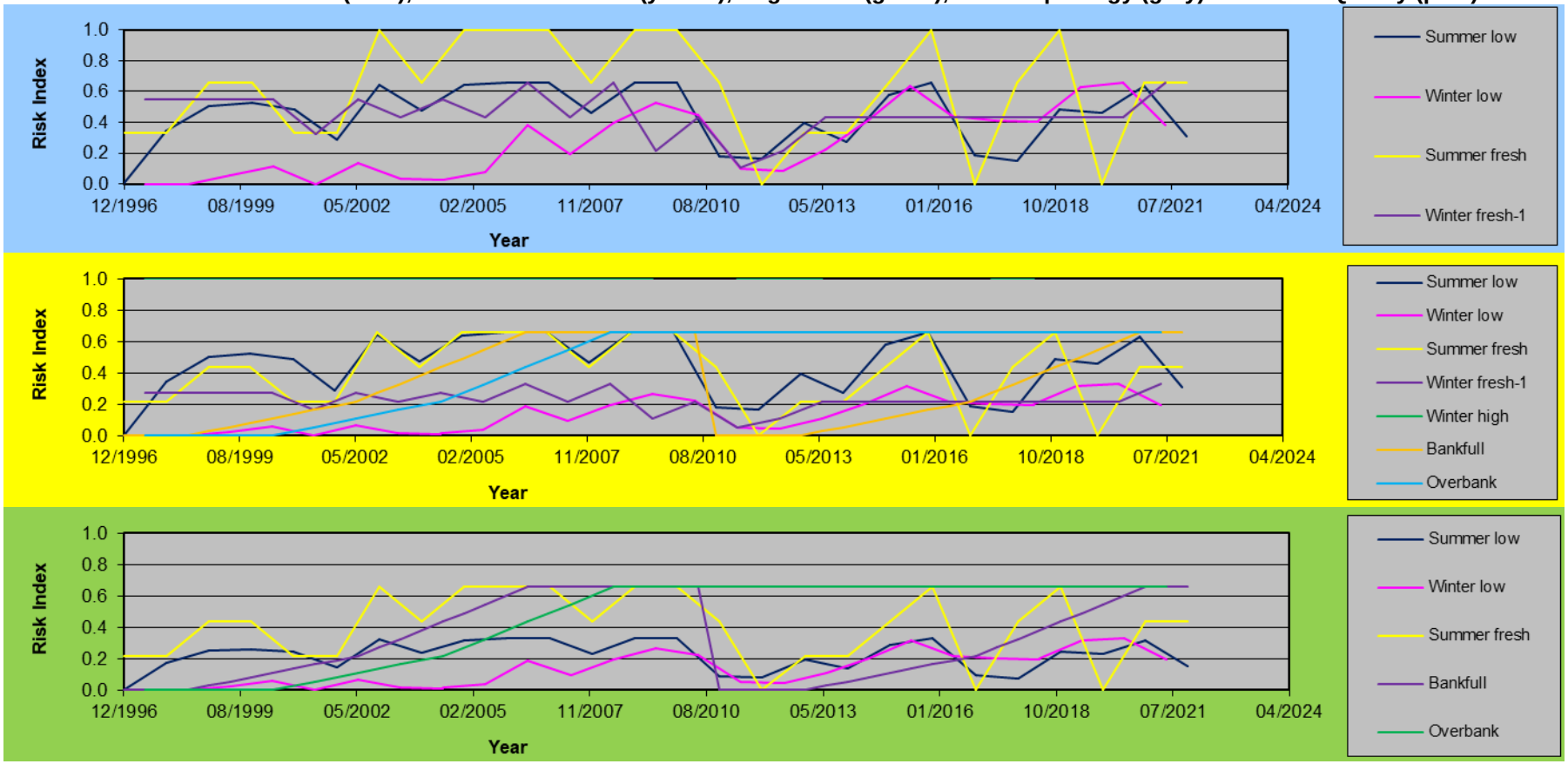
PWA delivered for lower Mt Wiliam Creek	Flow magnitude/ duration/ frequency	Comment
Baseflow all year	5 ML/d or natural	Limited flows due to low water availability in Lake Lonsdale and concerns over water quality. A combination of water transfers, unregulated flows and passing flows were able to provide some baseflows.

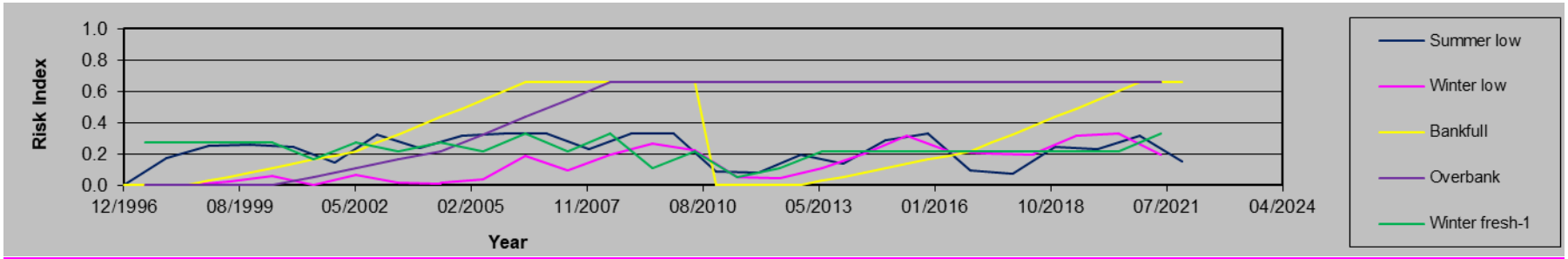
PWA delivered for lower Mt Wiliam Creek	Flow magnitude/ duration/ frequency	Comment
Summer/autumn freshes	20-30 ML/d 2-7 days x 3	One achieved via passing flows (February) the rest may be provided in autumn from passing flows in Lake Lonsdale if water quality is suitable.
Winter/spring freshes	100 ML/d 3-7 days x 1-5	Unable to be provided due to low water availability in Lake Lonsdale and concerns over water quality.
Winter/spring freshes	500 ML/d 1-3 days x 1-3	Unregulated flows insufficient to provide component. (Not regulated water objective). Dry-Wet years only.
Any time bankfull	750 ML/d 2-4 days x 1 or natural	Unregulated flows insufficient to provide component. (Not regulated water objective). Average-Wet years only.
Overbank	1,500 ML/d 1 day x 1	Unregulated flows insufficient to provide component. (Not regulated water objective). Wet years only.
PWA delivered for upper Mt Wiliam Creek	**Flow magnitude/ duration/ frequency**	**Comment**
Refuge pool filling	N/A (150 ML total)	To take place in April due to unregulated flows continuing to January meaning that the refuge pool has retained high water levels.

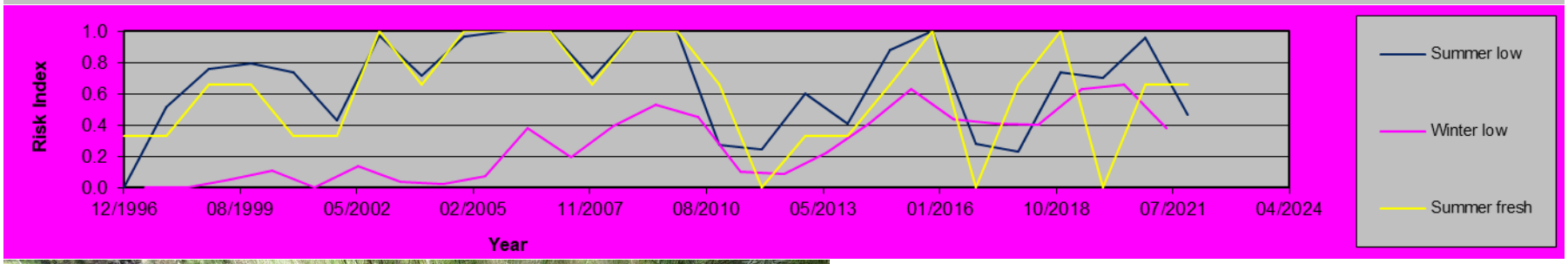
Pool containing fish at Lake Lonsdale Outlet (top) and Australian Smelt (bottom left) and Common Galaxias (bottom right) relocated from pool in February 2022. (Photos: B. McInnes)

Risks to ecological and physical objectives for the lower Mt William Creek is included in Table 24 below. The results highlight that risks remain steady due to the dry conditions although additional summer/autumn freshes will lower this risk. The risk posed by shortfalls in winter/spring low flows are not representative of the risk to the entire reach (given the gauge is immediately below Lake Lonsdale) which receives unregulated flows from tributaries like Briggs and Mud Hut Creeks.The absence of bankfull flows in recent years is a key factor in the high risk levels for several ecological values.

Table 24. Risk indices for Fish (blue), Macroinvertebrates (yellow), Vegetation (green), Geomorphology (grey) and Water Quality (pink) for lower Mt William Creek.







Dadswells Bridge Weir on Mt William Creek, November 2021

6. 2022-23 Priority watering actions

With inflows in 2021-22 again being comparatively low compared to historical averages, there have been modest allocations, reaching 57% in March 2022 for the VEWH regulated entitlement which mirrors allocations in 2021. No allocation for the CEWH product can again be foreseen in 2021-22 under any scenario and it would be very unlikely to receive one in 2022-23. Ongoing dry conditions since 2017 have meant a continued conservative approach to watering, congnisant of the need to set aside reasonable volumes of carryover for future years should conditions remain dry. Reasonable contributions from unregulated and passing flows in both the Wimmera and Glenelg systems means that some authorised volumes should remain unused going in to 2022-23. This means that targeted carryover volume of 24 GL should be achieved. Therefore ongoing drought refuge protection actions can take place intended to prevent critical losses, but they fall well below the minimum recommended watering requirements under a drought scenario. Actions like water trade or use of the Wimmera Mallee Pipeline to fill refuge pools as per the *Wimmera River Drought Refuge Management Strategy* (Alluvium, 2018) should continue to be given consideration by VEWH and DELWP given the comparatively low allocation situation and long timeframe required to implement such actions. In 2021, management plans were developed for these refuge pools to improve the collective understanding of the approach to and benefits from watering them and Wimmera CMA is progressing actions to fill some of the knowledge gaps identified in the process.

Given at least 59,345 ML is needed to deliver all Priority Watering Actions (PWAs) for the Wimmera River system in wet conditions (not including the terminal lakes) from a combination of regulated, unregulated and passing flows, wet conditions are required to provide unregulated and passing flows as well as boost allocations to avoid shortfalls. Wet conditions also provide high flow rates (e.g. bankfull flows) that cannot be provided by regulated watering actions. Priority Watering Actions are outlined initially in Table 25 and in further detail in Appendix 4.

6.1 Wimmera River Reach 4 Priority Watering Actions

Reach 4 of the Wimmera River is a priority reach based on managing risks to environmental values and the critical role of flow in maintaining water quality for aquatic and riparian ecosystems. Delivering PWAs to this reach will also facilitate social outcomes such as fishing and waterski competitions as well as rowing regattas through improved water quality in town weir pools. In 2022-23 flows, particularly from late spring to autumn will be critical to sustain habitat and water quality to levels that reduce the risks of extreme events like fish deaths and major algal blooms. These events have a very high risk of occurring if priority watering actions do not take place given the relatively limited flows that have occurred since 2017 and resultant high nutrient levels. During drought conditions like 2014-15 the Wimmera River did not flow beyond Dimboola for 18 months, leading to extremely high salinities and lack of habitat with all but the deepest pools drying out and so flows will be vital in preventing such impacts.

The ability to provide regulated water will be critical for trying to manage potential blackwater events (such as that experienced in February 2021) and/or hypersaline conditions. The limited flows from the upper catchment since 2016 have meant that large quantities of organic material continue to build up in some areas and could create blackwater conditions again should there be a small flow from the upper catchment that can mobilise the organic matter but not provide sufficient subsequent flows to maintain dissolved oxygen levels. Likewise, with increasing salinity levels, there is a need to provide the necessary flows for adequate dilution to avoid mobilising and transporting a slug of hypersaline water downstream.

Another priority watering action will be the provision of a fresh in late spring to try and trigger Golden and Silver Perch movement and breeding such as that witnessed on the back of a natural event in November 2021. More broadly, improvements in aquatic vegetation in response to improved water quality and concerted carp removal work in recent years have been vital for maintaining dissolved oxygen levels, providing habitat and supporting species like glass shrimp which in turn have been a ready food source for small-bodied and juvenile large-bodied native fish. The relatively stable water levels and better water quality provided by environmental watering activities have also supported phytoplankton and zooplankton populations that are vital for productive food web. There is a strong expectation by communities that live near the Wimmera River for environmental watering to maintain water levels and quality which in turn provides recreational and aesthetic benefits. Flows in this reach will also assist with the planned watering of Ranch Billabong to boost riparian and wetland plant condition, in conjunction with cultural outcomes.
So in summary, the priority watering actions pertain to:

- Winter-spring baseflows and freshes to improve water quality and access to habitat along the river with a spring fresh to try and trigger native fish spawning; and
- Summer-autumn baseflows and freshes to offset impacts of salinity and evaporation/seepage on refuge pools throughout the river but particularly downstream of Dimboola.

6.2 MacKenzie River Reach 3 Priority Watering Actions

Very high environmental values mean that the MacKenzie River continiues to be a high priority for environmental watering. Important populations of indigenous fish species, platypuses and riparian vegetation rely on flow in the MacKenzie River to persist and disperse, especially given the fact that pools do not persist for long periods due to their almost unique morphology. Southern Pygmy Perch and Obscure Galaxias are clinging on in refuge pools that have been regularly topped up with environmental water since 2018.

Surveys in Reach 3 show the ongoing presence of *Flora and Fauna Guarantee Act*-listed Western Swamp Crayfish (Ecology Australia, 2019) therefore making it a priority for ongoing environmental water delivery. This crayfish species does not create its own burrows to live in when waterways dry out and so will die unless it can find a burrow created by other species (i.e. Common Yabby). Should conditions remain dry then the focus will continue to be on maintaining the refuge pools in the upper-mid section of Reach 3 through intermittent baseflows given the continuing modest volumes available from Lake Wartook and Moora Moora Reservoir (Figure 10, pg. 32). Unfortunately, it is unlikely that there will sufficient volumes available to maintain shallower pools in the reach and the large refuge pool at the McKenzie Creek Reserve Gauge, which is the most downstream significant refuge pool. However this pool is located in an outcropping section of sandstone and so retains water comparatively well compared to upstream pools that are underlain by sand and/or clay although surveys in 2020 indicate that the fish population has disappeared given the inability to regularly water it in 2019-20.

Should conditions improve with wet-average conditions over winter/spring 2022 then priority watering actions will revert to fulfilling environmental flow recommendations with a focus on:

- Regular freshes/baseflows over summer/autumn combined with periodic cease to flows that may be beneficial in limiting the growth of the Eastern Gambusia population in this reach (Ecology Australia, 2014). Gambusia are a small-bodied, aggressive pest fish species that compete with native fish and frog species for habitat and resources. Indications are that cease to flows are also important for the growth and recruitment of aquatic vegetation in this reach given the shallow water/mudflat habitat they provide (Chris Jones, ARI, *pers.comm.*) The cease to flows are not to be too long such that water levels decline too much, particularly during September-January which are important times for Southern Pygmy Perch breeding and survival outcomes;
- A fresh in late autumn will assist in the dispersal of juvenile platypuses into this reach (Melody Serena, Australian Platypus Conservancy. *pers. comm.*) This is becoming increasingly important as platypuses appear to have fully repopulated the upstream reach;
- A six to seven day fresh has been recommended for this reach in August/September for vegetation outcomes and low flows in autumn will assist in the germination of Water Ribbons (*Cycnogeton sp.*) (Chris Jones, ARI, *pers.comm.*) This is complemented by watering in late spring and early summer that enables aquatic plants to maintain condition to complete seed growth and downstream dispersal; and
- Winter flows are also recommended for this reach to facilitate Obscure Galaxias spawning and larval survival (Ecology Australia, 2017a).

Water quality in the MacKenzie River is typically excellent so flows in this reach help enhance water quality in the Wimmera River and there are typically high levels of organic matter that can be delivered to the Wimmera River as a source of carbon during the cooler months. Prior to spring 2016, due to drought conditions, Reach 3 was completely dry for almost 18 months so native fish and other water-dependent fauna populations have since recolonised parts of this reach although they remain under severe pressure given the dry conditions since 2018. Not providing water to at least protect the refuge pools in Reach 3 will eliminate these gains. The high environmental values of the MacKenzie River provide several flow-on social benefits through the numbers of people who enjoy fishing and birdwatching when environmental water releases are taking place. There was also some community outcry to the lack of flows along the lower MacKenzie River in 2019-20 with an online petition being established.

6.3 MacKenzie River Reach 2 Priority Watering Actions

The MacKenzie River Reach 2 supports the source population of indigenous fish that populate MacKenzie River Reach 3 and Burnt Creek during wet conditions. Platypuses appear to have fully recolonised this reach after disappearing in 2007 when the reach dried out. Expanding the size and spread of the threatened platypus population in the MacKenzie River is vitally important as the upper Wimmera River population is now functionally extinct (Josh Griffiths, cesar, *pers. comm.*). Also having the River Blackfish population expand along the length of Reach 2 (and ideally into Burnt Creek and Reach 3) is a long-term goal of environmental water management in this reach. Wimmera CMA is almost ready to upgrade the fishway at Dad and Dave Weir to improve the ability for fish to disperse upstream and downstream from Reach 1 to Reach 2. River Blackfish remain confined to the top of Reach 2 in small numbers and so having suitable habitat for them to repopulate is important as they can rapidly recolonise areas should conditions be suitable (Zeb Tonkin, ARI, *pers. comm.*) and the good numbers in Reach 1 can make their way downstream.

Priority Watering Actions for Reach 3 typically remove the need for Priority Watering Actions for Reach 2. However if conditions are exceptionally dry and preclude delivering water to Reach 3 then small volumes will be required to support the environmental values in Reach 2.

6.4 Upper Burnt Creek Priority Watering Actions

As with MacKenzie River Reach 3, priority watering actions may be confined to drought refuge management if conditions in 2022-23 are again dry. Refuge pools have been identified at the upper, mid and lower section of this part of Burnt Creek (Figure 9, pg. 31). With improved but still only modest volumes of water available from Lake Wartook and Moora Moora Reservoir if conditions remain dry, then the priority will be to maintain these pools through intermittent flows from late spring through to late autumn. Unregulated flows should maintain them during winter and early spring.

Should conditions improve, year-round baseflows will assist the restoration and maintenance of fish communities in the upper reaches of Burnt Creek, especially when in combination with the strong aquatic vegetation growth and recruitment observed in recent years. Populations of the *FFG Act*-listed Western Swamp Crayfish have been identified in this reach of Burnt Creek (Biosis, 2013, Ecology Australia, 2017) and surveys in November 2020 and April 2021 continue to find them. Like the MacKenzie River, this section of Burnt Creek is valued by the local community which like to see regular flows and the environmental benefits they provide, especially in light of the continued improvements in the last ten years due to regular environmental watering.

Burnt Creek is supplied from the MacKenzie River or Moora Moora Reservoir and so is therefore highly regulated, without environmental watering the only flows taking place along this reach are typically transfers of inflows into the mid-MacKenzie River to Taylor's Lake in winter/spring. Therefore, environmental water releases will be critical to supplement these flows, especially in the drier months. During winter/spring baseflows and freshes are typically provided by catchment pickup or transfers from Moora Moora Reservoir or Lake Wartook to Taylor's Lake or releases to lower Burnt Creek, particularly if conditions are average or wet. This will offset the need to make a specific release to target outcomes in the upper Burnt Creek. A two to three day fresh has also been recommended for this reach in August/September for vegetation outcomes (Chris Jones, ARI, *pers. comm.*) which also aligns with the flow recommendations although this should be able to be provided by unregulated flows unless conditions are exceptionally dry. Also, as with the MacKenzie River, low flows in autumn provided by environmental watering will assist in the germination of Water Ribbons (*Cycnogeton sp.*) and later flows will aid their growth and recruitment.

6.5 Lower Burnt Creek Priority Watering Actions

Lower Burnt Creek has valuable riparian vegetation in some sections which provides important habitat for terrestrial and aquatic species. Releases in previous years have been noted to lead to enhancement in the presence of frogs and waterbirds, including one of the first discoveries of a Peron's Tree Frog in the region. Environmental water releases provide a lifeline for maintenance of its values given the complete absence of flow from this reach apart from in periods of flood due to its extremely high levels of regulation. Despite the limited flows, a reasonable diversity of native fish species was captured in this section of the creek in November 2017 which have moved downstream from the Upper Burnt Creek, indicating the potential environmental outcomes that can be achieved. Unfortunately, the absence of flows over summer meant that these fish disappeared. It is anticipated that if water availability substantially improves then these fish outcomes could then be pursued again. Previous fish monitoring results were fairly disappointing which is somewhat attributable to the effect of barriers to fish movement from upstream (Biosis, 2013). However, the use of an undershot weir gate to pass flows through to this reach in conjunction with a pipe outlet (instead of just the pipe outlet) seems to be improving this situation. This is evidenced by fish surveys by ARI in April 2021 which showed the return of a small population of Southern Pygmy Perch and Obscure Galaxias to the most upstream section of this reach. Even more significant was the finding of a large number of threatened Western Swamp Crayfish (33) which have colonised the reach from the upper Burnt Creek and are thriving in the organic debris present in pools. As mentioned previously, like fish, they need water to survive, unable to create burrows to aestivate.

There is a contrast in the morphology of the lower compared to upper Burnt Creek in that it still retains a larger number of deep pools which can contain water for long periods (>1 month). However it has been noted that areas of phragmites are expanding due to the infrequent watering, meaning that currently water levels are not high enough for long durations to confine their growth to pool margins. A passing flow for the creek has been recommended as part of the review of the storage management rules which may be able to meet some PWAs when it is eventually implemented. There is a strong desire amongst adjacent landholders to see increased flows for this reach and there has been good uptake of riparian enhancement projects to increase its environmental values.

Approximately 150 – 200 ML is required to fill pools in the creek before the PWA of a bankfull flow can take place which is now able to be achieved (if water is available) due to the upgrading of an undersized culvert across the creek by Horsham Rural City Council (funded by Wimmera CMA) in 2019.

6.6 Bungalally Creek Priority Watering Actions

Bungalally Creek has riparian vegetation in some sections which provides habitat for terrestrial and aquatic species (e.g. frogs) and due to high levels of regulation, it only receives flows in times of flood or environmental water releases (like lower Burnt Creek). The on-going collaboration between the Storage Manager and Wimmera CMA will be important for maximising the opportunities and outcomes from system water that can be directed to the creek if there are very wet conditions, as what happened in 2016 and 2017. A passing flow for the creek has been recommended as part of the review of the storage management rules which may be able to meet some PWAs when it is implemented. Local landholders have a strong interest in the maintenance and enhancement of its riparian ecological values. In April 2019 Horsham Rural City Council upgraded a stream crossing that may be impacted by the PWA (Earth Tech, 2006) with funding provided by Wimmera CMA. Like the lower Burnt Creek, this will reduce risks and maximise outcomes should the PWA take place.

Due to the high level of regulation of this system and the fact that it would only receive flows during high flow events, the creek bed will most probably be completely dry when watering commences. Previous experience shows that about 100 ML is required to enable this reach to be filled and connected before the PWA (bankfull flows) can be delivered.

6.7 Upper Mt William Creek Priority Watering Actions

The upper Mt William Creek supports good populations of endemic fish species and there are no European carp present in this reach due to the downstream barrier of Lake Lonsdale (Biosis, 2012). Following wet conditions in 2010-2011, several dry years caused Lake Lonsdale to dry out in 2015. Good inflows in 2016 led to it reaching its maximum operating level but water levels have been steadily declining since then with the lake only being 13% of the maximum operating level in March 2022. The lake has been fluctuating from up to 20% down to 5% of its maximum operating level since late 2018 with the modest inflows enough to introduce more salt and nutrients to the lake but not enough to significantly dilute them or provide large volumes for outflows through environmental flows and/or water transfers. This means water quality is steadily declining in the lake.

The small section of the creek upstream of Lake Lonsdale at Mokepilly can provide crucial drought refuge for endemic fish species although its values are diminishing on the back of a series of dry years impacting on habitat and recruitment. Protection of fish habitat in this reach with summer-autumn flows is considered important for maintenance of the fish community in this reach (SKM, 2005). The fish community in this reach in turn replenishes Lake Lonsdale during wet years, which like many lakes in the district, provides a significant drawcard for anglers. With a dry or almost dry Lake Lonsdale, this PWA may be required if again winter/spring proves to be dry. A regulator has been constructed to deliver water to this location in early 2017, prior to this pumping or temporary structures were required to provide water to the refuge pools in this reach. The PWA has not related to a flow rate but rather topping up refuge pools to ensure that they provide meaningful habitat through engaging the large beds of Water Ribbons (*Cycnogeton sp.*) at the site. This has been successfully undertaken in the past, triggering Southern Pygmy Perch breeding events (Austral, 2016).

6.8 Lower Mt William Creek Priority Watering Actions

Maintenance of intact native fish populations in the lower Mt William Creek in order to facilitate dispersal to the Wimmera River is considered important, as is the need to provide flushing flows to prevent major declines in water quality (salinity) and habitat availability. The creek has had a fish population that is almost unique in the Wimmera with a mix of species that are found in more headwater streams (Southern Pygmy Perch, Obscure Galaxias, River Blackfish) with lowland species (Golden Perch, Flathead Gudgeons, Australian Smelt). Monitoring results are highly variable from year to year which are potentially indictive of the importance of the emigration of species from upstream and downstream and challenges with sustaining meaningful fish populations in this reach over a series of years given the vast fluctuations with water quality and water availability. Unless 2022 is a very wet year, there is a prospect that Lake Lonsdale will dry out or be at such low levels that PWAs from this source are not feasible in 2022-23, as has largely been the case since 2020.

The ongoing challenge is to balance the provision of habitat with the fact that environmental water supplied is typically much poorer quality than the receiving waters, especially with Lake Lonsdale at low levels. Unregulated flows from the northern Grampians during winter/spring have typically excellent water quality with salinity levels about 10% that of those in Lake Lonsdale. There are concerns about the impact of poor water quality on fish populations in this reach given impacts in the last few years like blue green algal blooms and fish death events. Also compounding this is the periodic use of flows from Lake Lonsdale (when it is at high levels) to provide demands for the Wimmera River and also during a series of dry years the lake dries out which prevents flows for this reach. This means the delivery of environmental water for the Upper Mt William Creek becomes even more critical.

This reach also contains very high value macroinvertebrate and vegetation communities given it flows through or near large tracts of public land, particularly the Grampians National Park. The presence of Lake Lonsdale at the top of this reach and historical diversions for consumptive supply means that this reach has been one of the most flow-stressed in all of Victoria (SKM, 2005a). A week-long fresh has been recommended for this reach in August/September to achieve vegetation outcomes (Chris Jones, ARI, *pers. comm.*) which also aligns with the flow recommendations. Also low flows in autumn will assist in the germination of Water Ribbons (*Cycnogeton sp.*). This reach also flows through the locality of Dadswell's Bridge which has made a concerted effort to improve the community benefits of the creek through construction of a heritage walking trail focussing on the creek. However the small weir in the creek at Dadswells Bridge has created issues with anoxic water and odours, trapping much of the organic matter flowing down the creek. This is believed to have contributed to a small fish death event in January 2022 (about 10 adult carp).

Typically there have been opportunities to achieve these PWAs through passing flows or regulated releases from Lake Lonsdale to meet objectives in the lower Mt William Creek and Wimmera River. However this has not always been the case, especially under ongoing dry conditions and shifting operational arrangements. Therefore there is a need to specify specific PWAs for this reach given demands for the Wimmera River are more likely to be provided from Taylor's Lake given the low levels and poor water quality in Lake Lonsdale in early 2022.

6.9 Ranch Billabong Priority Watering Actions

Five watering events have taken place at The Ranch (December 2018, March and October 2019, June 2020 and October 2021). They have been successful in raising water levels and significantly dropping salinity. The watering has also led to a rapid responses from frogs and waterbirds. The salinity levels rise in the months after water was supplied and so additional watering events continue to be recommended to further dilute salinity levels and provide suitable habitat for frogs and ducks. It has also generated significant improvements in the health of River Red Gums currently experiencing stress from the dry conditions and saline water remaining in the billabong. There have also been improved conditions for culturally significant vegetation species like Old Man Weed/ Sneezeweed (*Centipeda cunninghamii*) and there is a wide range of birdlife that inhabit the site. Furthermore, watering increases the aesthetic appeal of the site which has been a focus for extensive onground works (weed removal and creation of walking trails and board walks) by Barengi Gadjin Land Council. Watering the billabong again in winter/spring 2022 is expected to continue the positive trajectory it is experiencing.

6.10 Dock Lake Priority Watering Actions

Successful outcomes such as Whiskered Tern and other waterbirds breeding following the water provided to the lake by unregulated flows/spills in spring 2016 indicates the value of Dock Lake remaining a PWA in line with the environmental flow study for the lake (Jacobs, 2015). Given the episodic nature of wetland watering in the Wimmera, and the low water availability leading into 2022-23 the PWA only applies during wet conditions. Environmental water delivery would need to ensure that Green Lake (through which water must be routed to reach Dock Lake) would not increase in volume as a result with water being outfalled at the same water level when inflows commence. This currently requires Green Lake to be nearly full, given the outfall at lower lake levels has silted up as it has not been used as a water supply storage for decades. Green Lake is likely to have high water levels in wet conditions from inflows from its own catchment and Storage Manager operations to protect water quality in Taylor's Lake. Green Lake also received a top up in 2021 with water purchased by Horsham Rural City Council from GWMWater so less water will be required to reach Dock Lake than in early 2021 when the lake was much lower (if the PWA had occurred).

Floating wetlands at Dimboola have been successful in mitigating erosion and enabling the colonisation of emergent vegetation (Photo: Alluvium, 2021)

7. Scenario Planning

Table 25. Summary of the Wimmera System environmental conditions, ecological objectives and environmental water requirements under a range of climatic (inflow) scenarios. Probability of Exceedance (POE) indicates likelihood of inflows being less than the % indicated based on historic inflows (e.g. a 95% Probability of Exceedance year means 95% of years will have greater inflows).

Wimmera River System	DROUGHT 95% POE		VERY DRY 90% POE	DRY 75% POE	AVERAGE 50% POE	WET 25% POE
Allocation against environmental entitlements (VEWH shared with Glenelg and not including Glenelg compensation flow)	VEWH Allocation	5,678 ML (14%)	12,574 ML (31%)	23,119 ML (57%)	32,854 ML (81%)	40,560 ML (100%)
	CEWH Allocation	0 ML	0 ML	0 ML	0 ML	0 ML
	VEWH Carryover 21,400 ML, CEWH Carryover 0 ML					
	Spill loss 0 ML		Spill loss 0 ML	Spill loss 0 ML	Spill loss 0 ML	Spill loss 0 ML
	Total Available 25,402ML		Total Available 32,297 ML	Total Available 43,532 ML	Total Available 54,645 ML	Total Available 64,765 ML
Assumed available to the Wimmera in 2022-23	7,000 ML		8,000 ML	11,500 ML	16,500 ML	21,500 ML
Expected climatic conditions and water available	Effectively no unregulated or passing flows (< 1000 ML total flows at Glenorchy)		Very little unregulated flow (~ 2000 ML for the Wimmera River at Glenorchy)	Some unregulated flows (~ 10,000 ML for the Wimmera River at Glenorchy)	Good unregulated flows (~ 50,000 ML for the Wimmera River at Glenorchy)	Significant unregulated flows (>100,000 ML for the Wimmera River at Glenorchy)
Expected river conditions (inc. unregulated and, consumptive water)	Periodic unregulated flows for Reach 2 MacKenzie River, Upper Burnt Creek, lower Mt William Creek. Regulated releases provide flows at other times and locations		Periodic unregulated flows for Reach 2 MacKenzie River, Upper Burnt Creek, lower Mt William Creek. Regulated releases provide flows at other times and locations.	Periodic unregulated flows for Reach 2 MacKenzie River, Upper Burnt Creek, lower Mt William Creek. Regulated releases provide flows at other times and locations apart from modest passing flows.	Regular unregulated flows for Reach 2 MacKenzie River, Upper Burnt Creek, lower Mt William Creek. Reasonable passing flows and unregulated releases for the Wimmera River and lower Mt William Creek. Regulated releases provide flows at other times and locations.	Regular unregulated flows for Reach 2 MacKenzie River, Upper Burnt Creek, lower Mt William Creek. Frequent passing flows and unregulated releases for the Wimmera River and lower Mt William Creek. Regulated releases provide flows at other times and locations
Estimated Passing Flows	0 ML		2000 ML	5000 ML	15,000 ML	50,000 ML
VEWH Carryover target 2023-24	11,402 ML		13,297 ML	20,532 ML	30,645 ML	21,500 ML

Table 26. Priority Watering Actions for 2022-23 – Wimmera River System

Waterway	Reach and Compliance Point	Action	Timing	Watering Effects	Environmental Objectives	Scenario	Tier 1a volume (ML)	Tier 1b volume (ML)	Rationale	Details about and differences between scenarios
Wimmera River	Reach 4 – Wimmera River at Lochiel (415246) although Extreme Drought and Drought scenario PWAs will be unlikely to reach the compliance point. (Note PWAs will benefit Reach 3 – Wimmera River at Horsham (415200)	Baseflows and freshes	Summer-autumn	Baseflows will dilute and flush saline water that intrude from groundwater systems. It will refill and maintain water levels in refuge pools and periods of connectivity to provide habitat during a time of year where they are affected by high temperatures (i.e. pools do not dry out or become too shallow and hot). Freshes provide additional mixing/dilution benefits for salinity outcomes and may also assist with creating localised reoxygenation effects in case of blackwater events. Inundation slightly higher up on bed/banks/benches also provides soil moisture for fringing and riparian vegetation to access to maintain condition.	Maintain suitable conditions to reduce risks of fish deaths and blue green algal blooms as well as provide suitable habitat to prevent major declines in native fish, macroinvertebrate and aquatic/riparian vegetation communities. Also provision of suitable habitat during this time of year will enhance survival of juvenile native fish species and food sources like shrimp, zooplankton and macroinvertebrates.	Drought	3850	7595	Critical for refilling pools and managing hypersaline conditions over warmer months to prevent substantial losses of fish population etc. **Note: Ideally some volumes would be able to be provided by Wimmera Mallee Pipeline outlets connected to refuge pools.**	Period of winter-spring baseflow may extend across into this time to try and avoid critical loss due to water quality impacts. Tier 1a has approx. 1 month baseflows but no freshes, 1b has 1 fresh and extends baseflow duration.
						Very Dry	3850	7595		Tier 1a baseflows will be unlikely to reach compliance point but extend the length of river channel that will be refilled to Dimboola. Tier 1a has no freshes, 1b has 1 fresh and extends baseflow duration.
						Dry	5150	6820		Will extend the duration of baseflows to approx. two months and length of river channel that will be refilled to the end of the river. 2 freshes provided. Tier 1b extends baseflow duration to 4-5 months.
						Average	7000	4970	Enhancing conditions over summer-autumn will lead to improved outcomes for recruitment events for fish, macroinvertebrates and vegetation. It will avoid the extremely high salinity levels noted along the river in locations like Tarranyurk and Wail after extensive periods of no flow (weeks-months).	As above but longer baseflows based on increased volumes will be important for reducing duration of cease to flows and resultant deterioration of water quality (salinity) and habitat (declining water levels). 2 freshes provided and Tier 1b extends baseflows to 5 months.
						Wet	9000	3495		As above but Tier 1b extends baseflow duration to 5 months to further improve connectivity and water quality. 3 freshes provided of >7 days (normally >2 days).
		Baseflows and freshes	Winter-spring	Baseflows will dilute and flush saline water, refill or maintain water levels in refuge pools and connect pools at a time of year when water-dependent species are typically within the recruitment phase of life cycles and so benefit from the maximising of wetted habitat for access/food resources. The higher flow rate of baseflows increases water depth between pools beyond summer/ autumn baseflows.	Maintain pool levels and connectivity to create suitable conditions for some macroinvertebrate and small-bodied fish species to breed (e.g. Flathead Gudgeons) and move (e.g. Australian Smelt, Golden Perch). Also provides a productivity function with carbon nutrient cycling and disturbing sediments in the substrate and biofilm on snags and rocks. Inundation of bed/banks also provides soil moisture for fringing and riparian vegetation to access	Drought	800	10290	Flow during winter-spring will take advantage of reduced losses from cooler weather and refill pools prior to the onset of summer. It will also transport organic carbon that has gathered in dry sections of channel, reducing blackwater risks.	Insufficient volume for a period of baseflow to reach end of river but protects refuges pools upstream of Dimboola. Tier 1a has no small freshes, Tier 1b has 1 small fresh and extends baseflow duration.
						Very Dry	1800	9240		
						Dry	4000	7470		Volume assumes that passing/unregulated flows will provide some flows but there will be cease to flow periods. Beyond a period of baseflows, Tier 1a has one small fresh, 1b has 3 small freshes, 1 medium fresh and extends baseflow duration.
						Average	3955	7400	Enduring and higher flows during winter-spring will provide enhanced nutrient cycling outcomes and has notable effect	Volume assumes that passing/unregulated flows will provide some flows but there will be cease to flow periods. Beyond period of baseflows Tier 1a has 3 small

Waterway	Reach and Compliance Point	Action	Timing	Watering Effects	Environmental Objectives	Scenario	Tier 1a volume (ML)	Tier 1b volume (ML)	Rationale	Details about and differences between scenarios
				Freshes increase water depth into shallow benches and helps transport organic matter (leaf litter, bark) that are a valuable source of carbon for instream productivity.	to maintain condition and enable successful recruitment.				on suppressing saline groundwater intrusion effects on surface water quality at Tarranyurk and Wail.	freshes, 1b has 5 small freshes and 2 medium freshes and extends baseflow duration
						Wet	4840	8510		Volume assumes that passing/unregulated flows will provide the bulk of the flows and there will be little/no cease to flows. As well as a period of baseflows, 3 small and 2 medium freshes to be provided under Tier 1a and Tier 1b to provide 2 additional small and 1 medium fresh.
Ranch Billabong	N/A – wetland is watered via pumping from Wimmera River at Dimboola Weir pool.	Refill (top ups after draw down)	1 winter and 1 autumn (if needed)	Will lift water levels, enhance water quality by diluting salinity and extend wetted perimeter to engage with wetland/ riparian vegetation. Water levels will decline between watering events.	Enhance the conditon of River Red Gums whilst enabling fringing and mudflat plant species to grow/recruit through the cycle of wetting/drying, creating a mosaic of water-dependent plant species.	All	15		Small volume involved for shared benefits and will continue positive trajectory for riparian/wetland vegetation and birdlife at the site.	N/A
MacKenzie River	Reach 3 – MacKenzie River at McKenzie Creek Reserve (415251) although only Average and Wet Scenarios will have sufficient water in PWAs to reach the compliance point. (Note PWAs will benefit Reach 2 – No compliance point available.)	Baseflows and Freshes	Summer-autumn	Baseflows maintain water levels in refuge pools, provides regular connectivity between pools and engages fringing vegetation. Freshes increase depth between pools and water levels on banks. The higher water levels also create additional biofilms on instream woody debris. Also flows are important to enhance dissolved oxygen levels given high organic loads.	Baseflows are needed to enable fish and platypuses to access habitat and avoid predation. Engaging fringing vegetation will also help with aquatic vegetation outcomes (pondweeds, water ribbons) that are also vital for fish outcomes (especially Southern Pygmy Perch recruitment and survival). Retention of water is needed to retain Western Swamp Crayfish population. Freshes are important for creating a mosaic of fringing vegetation (e.g. *potamageton sp.*).	Drought	1200	4400	Vital for refilling priority refuge pools for fish/crayfish preservation and providing connectivity for platypuses	Tier 1a will only water Reach 2 and upper Reach 3 refuges pools with baseflows and 4 freshes for Reach 2. Tier 1b enables watering of all Reach 3 with 3 freshes and a period of baseflows.
						Very Dry	1200	4400		
						Dry	1200	4400		
						Average	1700	4250	Period of low water levels in refuge pools can be reduced given their impact on small-bodied native fish due to increased Redfin predation	Tier 1a enables more frequent replenishment of refuge pools via longer baseflows. Tier 1b enables watering of all Reach 3 with baseflows and 4 freshes.
						Wet	2070	3880	Provides opportunity to protect fish/crayfish/ platypus populations that may have established at lower part of the reach and provide opportunities for emigration into Wimmera River.	Tier 1a enables 1 fresh, more frequent replenishment of refuge pools and periodic connectivity with Wimmera River via longer baseflows. Tier 1b enables watering of all Reach 3 with 4 freshes.
		Baseflows and freshes	Winter-spring	Higher baseflow rates compared to summer-autumn baseflows provide greater depths and connectivity (length of watering) which is important for transporting organic matter. Freshes increase depths further to facilitate movement of species as well as creating access to backwater areas given the river's rare anastomosing channel form.	Baseflows are needed to enable fish and platypuses to access habitat and avoid predation. Engaging fringing vegetation will also help with aquatic vegetation outcomes (pondweeds, water ribbons) that are also vital for fish outcomes (especially Southern Pygmy Perch recruitment and survival). The higher flow rates are important for movement and habitat access given the shallow morphology of much of the river and paucity of large refuge pools. It will help disperse high value species downstream along Reach 3 (and potentially into Wimmera River) and enable Obscure Galaxias to undertake migration. Retention of water is needed to retain Western Swamp Crayfish population.	Drought	200	3810	Flow will provide a top up for refuge pools and increased connectivity assuming unregulated flows have ceased in early spring	Tier 1a is just focused on refuge pool top up via a short period of baseflow. Tier 1b enables longer duration baseflows and 5 freshes with differences between scenarios relating to duration of freshes.
						Very Dry	200	3810		
						Dry	200	3960		
						Average	1530	3005	Provides opportunity to protect fish/crayfish/ platypus populations that may have established at lower part of the reach and provide opportunities for emigration into/from the Wimmera River.	Tier 1a enables more frequent replenishment of refuge pools and periodic connectivity with Wimmera River via longer baseflows and 1-2 freshes depending on unregulated contributions. Tier 1b enables longer duration baseflows and 5 freshes with differences between scenarios relating to duration of freshes.
						Wet	1530	3355		
Burnt Creek	Upper - Burnt Creek at Wonwondah East (415223) Lower - No compliance point available. (Estimated based on releases delivered at Burnt Creek Escape (Toolondo Channel))	Baseflows and Freshes	Summer-autumn	Baseflows maintain water levels in refuge pools and provide regular connectivity between pools and engages fringing vegetation. Freshes increase depth between pools and water levels on banks as well as creating additional biofilms on instream woody debris. Also flows are important to enhance dissolved oxygen levels given high organic loads.	Baseflows are needed to enable fish to access habitat and avoid predation when pools contract. Engaging fringing vegetation will also help with aquatic vegetation outcomes (water ribbons, milfoils) that are also vital for fish outcomes (especially Southern Pygmy Perch recruitment and survival). Retention of water is needed to retain Western Swamp Crayfish population including pools at the top of lower Burnt Creek. Freshes are important for creating a mosaic of fringing vegetation (e.g. sedges) and inundate very low benches.	Drought	700	1155	Vital for refilling priority refuge pools for fish/crayfish/mussel preservation and continuing gains in aquatic vegetation extent/abundance. Some flow also makes its way into lower Burnt Creek for fish, vegetation and frog outcomes.	Tier 1a is just focused on refuge pool top ups via baseflows with Tier 1b providing 3 freshes.
						Very Dry	700	1155		
						Dry	700	1155		
						Average	700	1155		Tiers 1a and 1b assumes some contribution from unregulated flows for baseflows with Tier 1b providing 3 freshes.
						Wet	700	1155		
		Baseflows and freshes	Winter-spring	Baseflows are important for maintaining water levels to engage woody habitat and fringing vegetation. Higher flow rates provide greater depths and connectivity (length of watered channel) and will flush sediments from substrates, creating additional intersitial habitat for macroinvertebrates. Freshes will	Baseflows are needed to enable fish to access habitat and avoid predation. Engaging fringing vegetation will also help with aquatic vegetation outcomes (milfoils, water ribbons) that are also vital for fish outcomes (especially Southern Pygmy Perch recruitment and survival). The higher flow rates will help create additional habitat for fish and macroinvertebrates and disperse high value species like Western	Drought	100	995	Flow will provide a top up for refuge pools for fish/crayfish/mussel preservation assuming unregulated flows have ceased in early spring due to dry conditions.	Tier 1a is just focused on refuge pool top up via a short baseflow. Tier 1b relates to providing small freshes (1 for Drought/Very Dry and 3 for Dry scenario) Average and Wet scenarios are not included for this reach as it is assumed that they will be met by unregulated flows and transfers in these scenarios.
						Very Dry	100	995		
						Dry	100	1355		

Waterway	Reach and Compliance Point	Action	Timing	Watering Effects	Environmental Objectives	Scenario	Tier 1a volume (ML)	Tier 1b volume (ML)	Rationale	Details about and differences between scenarios
				also engage low benches that are reappearing now the creek is being used less frequently for water transfers.	Swamp Crayfish downstream into lower Burnt Creek (and potentially into Wimmera River) and enable Obscure Galaxias to undertake migration. Retention of water is needed to retain Western Swamp Crayfish and Freshwater Mussel population.					
		Bankfull (Lower Burnt Creek only)	Winter-spring	Baseflow will be needed to fills pools prior to bankfull that provides a sufficient flow rate to reach upper margins of creek channel. Bankfull flow will mobilse organic matter and inundate the bank soil profile as well as fringing/aquatic vegetation.	Required to maintain condition of riparian vegetation (River Red Gum) given the creek only receives infrequent flows and important to reduce terrestrialisation of vegetation through improving conditions for riparian species. Will also help maintain fish, frog and macroinvertebrate populations that may have established in this reach under baseflow/fresh regime.	Average	400		Waters soil profile for riparian vegetation and reaches fringing sedges. Frog population in this reach is pronounced given limited fish population and predation of eggs/tadpoles.	N/A – short baseflow to fill (presumably) dry creek channel prior to 1 fresh.
						Wet	400			
Mt William Creek	Upper – Mt William Creek at Mokepilly (415252) Lower – Mt William Creek at Lake Lonsdale Tailgauge (415203)	Baseflows and Freshes	Summer-autumn	Baseflows maintain water levels in refuge pools, provides regular connectivity between pools and engages fringing vegetation. Baseflows and freshes mix and push saline water (from Lake Lonsdale) downstream and help reduce impacts of high organic loads on dissolved oxygen. Higher freshes also increase biofilm abundance on woody debris and increase water depth for increased dispersal opportunities.	Having refuge pools refilled and connected will help populations of Obscure Galaxias, River Blackfish and Southern Pygmy Perch to recruit and persist. Poor water quality and predation from Redin at low water levels have been major factors in the decline in the fish population in recent years. Water supplied from Lake Lonsdale is typically poor quality to flows are important to dilute and mix flows. Similarly, saline groundwater intrusions in the upper Mt William Creek lead to salinity impacts.	Drought	135	1315	Important to maintain water levels so that they do not recede to below level of band of water ribbons that exists at the refuge pool at Mokepilly that provides habitat for Southern Pygmy Perch and Flathead Gudgeon. Tier 1b relates to maintaining suitable refuge pool levels and water quality in lower Mt William Creek for native fish and macroinvertebrates.	Tier 1a involves filling Mokepilly refuge pool by baseflows only and assumes Lake Lonsdale is dry. Tier 1b assumes Lake Lonsdale contains usable water and can be used to provide baseflows and 3 freshes.
						Very Dry	135	1365		
						Dry	135	1275	Maintains refuge pool levels and minimises water quality declines in lower Mt William Creek for native fish and macroinvertebrates. Provides minor opportunities for emigration to Wimmera River.	Tier 1a involves filling Mokepilly refuge pool by baseflows only and assumes Lake Lonsdale does not contains useable water. Tier 1b assumes water in Lake Lonsdale to provide baseflows and provides 3 freshes.
						Average	900	585		As above but with higher fresh flow rate for 3 freshes.
						Wet	955	620		
		Baseflows and freshes	Winter-spring	Higher flow rates of freshes provide greater depths and connectivity (length of watering) for dispersal as well as entraining organic matter, engaging low benches and creating interstitial habitat by flushing sediments. Baseflows maintain pool levels.	Flows are needed to enable fish to access habitat and avoid predation. Engaging fringing vegetation will also help with aquatic vegetation outcomes (water ribbons) that are also vital for fish outcomes (especially Southern Pygmy Perch recruitment and survival). The higher flow rates will help disperse high value species downstream into Wimmera River.	Wet	1290	2950	Provides opportunities for high value species to emigrate downstream given they have been largely confined to upland areas in last few years.	Having this PWA in Wet scenario assumes reasonable passing flows available and water quality in Lake Lonsdale is suitable. Tier 1a volume provides baseflows and 1 fresh while Tier 1b volumes provides additional 4 freshes as per recommendations.
Bungalally Creek	No compliance point available (Estimated based on releases delivered at Bungalally Channel Outfall (Toolondo Channel))	Baseflow (to fill dry channel) and bankfull	Winter-spring	Baseflow will be needed to fills pools prior to bankfull flow that provides a sufficient flow rate to reach upper margins of creek channel to inundate soil profile to benefit riparian vegetation.	Required to maintain condition of riparian vegetation (River Red Gum) given the creek only receives infrequent flows and important to reduce encroachment of terrestrial vegetation species.	Average	300		It has been five years since this reach received reasonable flows and River Red Gum condition is declining.	N/A
						Wet	300			
Dock Lake	N/A – water delivered estimated based on water outfalled into Green Lake via Green Lake Channel.	Partial fill	Winter-spring	Creates low level inundation (typically <0.8m) across approx. 80% of the lakebed, drowning terrestrial grasses over several weeks.	Provides habitat for numerous waterbirds (e.g. Whiskered Tern, Grey Teal, Black-winged Stilts, Australian Shelducks, Purple Swamphens, Eurasian Coots) as well as several frog species. Also enables growth/ recruitment of wetland plants (e.g. nardoos).	Wet	400	600	Substantial wetland bird outcome for the volume involved based on observations and it has been five years since the wetland's last inundation which may impact on seedbed viability.	Tier 1a and 1b volume differences fall within the band of recommended low level inundation and allows for more seepage losses. Tier 2 is volume between recommended low level inundation and lake full supply level.

Scenario Planning Context

It is important to note that the Tier 1a volumes under all scenarios are well below those recommended to achieve compliance for PWAs based on the *Wimmera River Environmental Flows Study* (Alluvium, 2013) and are solely focussed on protecting priority drought refuges and avoiding critical losses based on best available information. It also recognises that due to the series of very dry years since 2017 there is very limited water availability and needs to be an emphasis on retaining some volume of carryover into 2023-24. Tier 1b reflects additional volumes required to obtain compliance with recommendations. Should additional volumes be available between scenarios then they will be allocated to in part deliver PWAs and bolster carryover reserves via the Western Rivers Advisory Group (WRAG) process through 2022-23. The WRAG process includes considerations around the Glenelg River given the shared VEWH entitlement and enables factors to be considered like the contribution of unregulated/passing flows and where regulated water may be accessed given some storages like Lake Wartook cannot be supplemented by transfers from other parts of the system. Appendix 3 contains more detail regarding PWAs in relation to ecological objectives and expected watering effects.

8. Delivery Constraints

The *Wimmera River System Environmental Water Management Plan* (Wimmera CMA, 2016) outlines delivery constraints in detail. Given the Wimmera-Mallee Headworks system was designed to harvest water to be released into the former stock and domestic and irrigation channel systems at comparatively modest rates, releases are only typically able to provide baseflows and freshes. Where bankfull and overbank flows are able to be provided (lower Mt William Creek, MacKenzie River and Burnt Creek) instream losses in swampy areas and risks to inundating freehold land make these releases unfeasible. Other features like the configuration of the Burnt Creek where it bisects the Toolondo Channel create issues with extra losses given the need to raise water levels in the channel before flows enter the lower Burnt Creek, although measures like sandbagging the channel lead to minor benefits. Upgrades to infrastructure in recent years at locations like Dad and Dave Weir, Distribution Heads and Lake Lonsdale Outlet to include automation and telemetry will assist with providing improved rates of rise and fall in flows with more regular flow rate changes possible.

The key delivery constraint in 2022-23 is likely to be the continuation of low levels in Lake Lonsdale and Lake Wartook (to a lesser degree) which means that unless there are significant inflows into these storages, many priority watering actions for the MacKenzie River, Burnt Creek, Bungalally Creek and Mt William Creek will be unachievable.

Wimmera CMA is also working with GWMWater to design an outlet into the Mt Cole Creek from the East Grampians Pipeline at Warrak. It is hoped that environmental water will be able to be supplied from the new outlet to protect high value refuge pools containing small bodied native fish and Western Swamp Crayfish. The pipeline outlet is anticipated to be constructed in 2022-23 as part of the broader pipeline construction works.

9. Confounding Factors

Environmental water can only achieve so much when it comes to maintaining and enhancing waterway condition and needs to be contextualised within the frameworks of integrated catchment management that Victoria has championed for decades. Factors that affect environmental outcomes in association with environmental watering are outlined in Section 7 of the *Environmental Water Management Plan - Wimmera River System* (Wimmera CMA, 2015). Key factors include the presence of hypersaline groundwater intrusions in the lower Wimmera River and upper Mt William Creek, high numbers exotic fish species (Redfin, Carp, Eastern Gambusia) and instream barriers such as weirs.

In 2021 Water Technology completed a project which follows on from mapping the extent and locations of phragmites and typha along the Wimmera River from Horsham through to Lake Hindmarsh in 2020 and comparing the results with that mapped in 2006 (Water Technology, 2020). The more recent work involved analysing the nutrients and biomass associated with the stands of phragmites to understand how water availability and quality are affecting their dynamics. It revealed the presence of high nutrient levels associated with the historic input of treated wastewater from Horsham and irrigation drainage from Quantong through to the 1990's (Water Technology, 2021). Therefore there is a legacy issue that will take decades to address with flows moving the high nutrient downstream through annual growth/breakdown cycling of phragmites and typha.

10. Increasing Knowledge

Monitoring of waterways is critical in order to better understand the effectiveness of environmental watering activities across a range of climatic conditions. This enhances community confidence in future environmental watering activities and enables adaptive management of future environmental flows.

Although this Seasonal Watering Proposal has been developed using the best available information there are still key knowledge gaps and recommendations that remain that can enhance environmental water management in the Wimmera for the benefit of the entire region. The key focus will be filling knowledge gaps identified in *Wimmera River (Barengi Gadjin) Drought Refuge Management Planning* (Streamology, 2021) particularly around water levels and quality (especially saline ground water intrusions). ARI is also currently developing the Wimmera Native Fish Management Recovery Plan which will provide a series of objectives for native fish in the region including the provision of environmental flows to enhance breeding opportunities for large-bodied species. Therefore monitoring work will be pivotal in order to understand the attainment or otherwise of that objective.

Environmental water deliveries are underpinned by an adaptive management approach. Compliance points for priority reaches are often some distance downstream, a higher release rate is required to cover instream losses through seepage, evaporation and diversion experienced between the delivery point and the compliance point. Therefore ongoing monitoring of flow rates at stream gauges enables environmental flows to be increased or decreased to efficiently meet recommendations. In time the current dataset will be increasingly refined to enable effective and efficient environmental water delivery through better understanding in-stream losses and timing of flows along various waterways.

Compliance monitoring is needed to show flows have been delivered in accordance with recommendations and at the times specified to target areas as precisely and as efficiently as possible. Locations where stream monitoring is needed include: Bungalally Creek, lower Mt William Creek at Dadswell's Bridge or Roses Gap, Reach 2 of the MacKenzie River near Distribution Heads Weir and lower Burnt Creek at the Western Highway crossing. If funded, the installation of these gauges will significantly improve environmental water managers' decision making through ensuring regulated releases are providing the recommended volumes at compliance points as well as quantifying the effect of various flow components on water quality. The installation of Portable Automated Logger System (PALS) unit at Roses Gap, funded by VEWH has been a valuable tool to inform decision making around environmental water releases and it is hoped that it will be repaired in coming months after malfunctioning in August 2021.

Given the substantial expenditure of public funds that has been undertaken to recover water for environmental flows there is a need to demonstrate the outcomes this will achieve. Recommended condition monitoring, required to document trends and provide context for intervention monitoring though answering key questions around flow-ecology relationships are listed below;

- Fish monitoring provides a valuable annual snapshot into the ecological response of environmental flows. Annually sites on the Wimmera River will be monitored as part of the Angler Report Card program instigated by DELWP although the focus is on angling species rather than small bodied species. Occasionally other fish monitoring programs (e.g. targeted intervention monitoring on the Mt William Creek, MacKenzie River and Burnt Creek) will complement this data;

- e-DNA sampling (including meta-barcoding) at key sites (e.g. Ranch Billabong, drought refuges, Toolondo Channel) to understand the range of species that use these sites and risks around carp movement;

- Should good water levels be present in regulated wetlands (Lake Hindmarsh, Dock Lake) bird monitoring will take place; and

- Continue annual platypus surveys using trapping and e-DNA sampling in the MacKenzie River with the option to include Burnt Creek if deemed worthwhile.

This year a project involving renowned ecologists Professor Peter Gell (Federation University) and Lance Lloyd (Lloyd Environmental) will be completed that understand more about the history of the flora and fauna of the Wimmera River system through analysing sediment cores from the Wimmera and MacKenzie River (for pollen, and DNA), historical records and local expertise. This will also establish further research priorities to enhance the understanding of what the Wimmera River system has been able to historically sustain.

Juvenile Flathead Gudgeon from the Wimmera River at Horsham, March 2022

11. Risk Management

Risk assessment and management is an important aspect of environmental water planning. A teleconference was undertaken with VEWH, Parks Victoria, Gunditj Mirring, CMAs and GWMWater on 25 February 2022 to discuss risk management and environmental watering in detail. Table 27 illustrates the various risks covered in this workshop (likelihood and consequence) associated with planned environmental flow components.

Table 27. Risks associated with environmental water release components planned for 2022-23.

Legend for Table

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 organisn. for action	Risk type (Static/ Dynamic)
1	Env	Insufficient water available for proposed watering actions to meet environmental objectives. *Note: there is a need to be alert to cumulative impacts of multiple dry years, and impacts on recovery due to back-to-back dry years. Wetlands are in drought refuge mode and have been for some years - relying on carry-over and significant vegetation impacts are threatening*	L	Maj	High	Adaptively prioritise and revise watering actions to optimise outcomes from water available considering seasonal conditions, including consideration the need to reserve contingency volumes for the following season. Identify any reservoir release constraints due to low water levels and adapt plans accordingly Maximise use of consumptive water en-route for environmental benefit. Communicate with community and stakeholders around planned watering actions and any revisions required. Undertake extra monitoring to guide complementary actions (e.g. carp removal, fencing). Undertake studies to identify key refuge areas for protection in the Glenelg and Wimmera systems. Where feasible, deliver water via pipelines to key drought pools on the Wimmera River Look for water savings to build up a "water bank" for reducing stress in subsequent years	CMA/WRAG CMA/WRAG GWMWater CMA CMA CMA CMA VEWH/WRAG	Dynamic

No.	Risk category[1]	Risk description	L[2]	C[3]	Risk rating	Mitigation actions	Lead organisn. for action	Risk type (Static/ Dynamic)
						(Note: This risk is still rated as medium after mitigation actions.)		
2	Env	Environmental water deliveries may generate or mobilise poor quality water (e.g. blackwater, BGA, salinity), with adverse water quality and environmental outcomes; or Areas not targeted for environmental watering actions experience poor quality water (e.g. blackwater, BGA), with adverse water quality and environmental outcomes	L	Min	Medium	Ongoing monitoring to inform water deliveries specifically from Lake Lonsdale. Adapt flow management based on antecedent conditions and local knowledge. Maximise use of consumptive water en route for environmental benefit. Establish environmental reserve to manage management needs. Communicate around current conditions and revised objectives. Undertake complementary actions, including provision of information to the community	WCMA CMA GWMWater VEWH CMA CMA	Static
3	Env	Environmental deliveries create improved conditions for non-native species (e.g. carp, invasive weeds, rabbits, foxes) leading to adverse environmental impacts. (*Note: This risk addresses the incremental impact of environmental water deliveries on pest plant and animal populations, noting that even in the absence of environmental delivery actions these pests are likely to spread in waterways with adverse environmental impacts).*	L	Mod	Medium	Adaptively manage flow to incorporate new knowledge from monitoring and research. Monitor invasive species extent and control existing populations (e.g. opportunistic removal of carp in dry conditions). Install physical barrier to prevent translocation (e.g. carp barriers). Develop management agreements with landholders that include pest plant and animal control measures. Communicate data from fish surveys etc. to inform the community on pest species and outcomes of control measures. Seek additional funding for carp control activities.	CMA CMA CMA CMA CMA CMA	Dynamic
4	Rep	Inability to demonstrate that environmental water objectives have been achieved, which	P	Mod		Seek additional funding for and undertake targeted local monitoring (leveraging existing data sets where possible).	CMA	Static

No.	Risk category[1]	Risk description	L[2]	C[3]	Risk rating	Mitigation actions	Lead organisn. for action	Risk type (Static/ Dynamic)
		may lead to a loss of public/political support for activities.				Invest in monitoring and research to address knowledge gaps and influence existing monitoring programs. Share new knowledge to promote adaptive management. Communicate monitoring results to local communities.	VEWH/ DELWP VEWH CMA	
5	Legal	Environmental releases cause unauthorised inundation of private land, resulting in impacts on landowner activities and assets. Includes unauthorised interference with delivery infrastructure	U	Mod	Low	Ensure the currency of any landholder agreements for environmental watering actions. Ongoing communication with GWMWater and land managers in planning and delivery phases. Consider weather forecasts when conducting environmental releases and reschedule deliveries if forecasts indicate potential for flooding. Test and monitor delivery rate and respond to potential incidents. Maintain and inspect infrastructure, including upgrading infrastructure where required before delivery occurs. Identify likely areas of impact by understanding historical impacts and previous experience, and modify flow planning, or undertake works to reduce risk of inundation. Install locks on infrastructure as necessary	CMA CMA GWMWater GWMWater GWMWater CMA Asset owners	Static
6	BC	Insufficient staff resources available to deliver all planned environmental watering actions, leading to cancellation or interruption of deliveries.	L	Mod	Low	Continue to actively prioritise actions to match available resources and ensure priority actions are delivered. Ongoing communication with GWMWater to understand constraints and develop a schedule of delivery to manage staff resources.	CMA CMA GWMWater	Static

No.	Risk category[1]	Risk description	L[2]	C[3]	Risk rating	Mitigation actions	Lead organisn. for action	Risk type (Static/ Dynamic)
						Implement remote monitoring to minimise staff time in the field, within available funding. Provide delivery plans with required lead time prior to target delivery date (usually 2 weeks). Ensure timely approval of seasonal watering statements. Upgrade infrastructure to reduce the need for manual operations. Adjust delivery timing to avoid holidays, weekends and high-risk periods for resourcing.	CMA VEWH CMA CMA	
7	BC	Volume delivered or released exceeds volume approved and/or ordered for use in the event or year.	U	Mod	Low	Communicate seasonal watering statements to all partners. Monitor delivery rate, provide delivery data to CMA/VEWH and respond to potential incidents. Monitor water use against volume approved for use in seasonal watering statement and adapt water orders if required. Monitor water use against volume approved and undertake regular communications with CMA and GWMWater as part of portfolio management activities. Review and update established ordering processes with GWMWater, (as documented in Operating Arrangements document) at regular intervals.	VEWH GWMWater CMA VEWH VEWH	Static
8	Safety	Where delivery structures are unsafe and have limitations on their operation, planned environmental deliveries may not be feasible leading to a failure to achieve environmental outcomes.	U	Ext	Medium	Upgrade or modify infrastructure to improve safety. Modify method of operation to avoid unsafe work practices and update safety procedures to reflect this (Note: safe work procedures will need to be communicated to community/volunteer	Asset owner Asset owner	Static

No.	Risk category[1]	Risk description	L[2]	C[3]	Risk rating	Mitigation actions	Lead organisn. for action	Risk type (Static/ Dynamic)
						resources as well as agency staff where they undertake structure operations).		
9	Env	Flow rate at environmental flow compliance point not able to be demonstrated, which may lead to failure to achieve target flows and environmental benefits not being achieved.	P	Mod	Medium	Install/upgrade stream gauge monitoring to improve ability to demonstrate target flow rate achievement. Consider data collection and modelling studies to improve understanding of flow behaviour of systems.	CMA CMA	Static
10	Env	Target flow rate at environmental flow compliance point not achieved due to environmental conditions, (for example high losses at very dry sites, hot weather causing excessive evaporation, antecedent conditions and inflow rates) and environmental benefits not being achieved.	L	Min	Low	Monitor flow rate and adjust delivery volume within approved volume. Use flow forecasting tools/modelling to better understand and allow for losses Arrange releases from weir pools to complement environmental deliveries. Consider adjusting delivery timing to avoid holidays, weekends and high-risk periods for system operations resourcing.	CMA GHCMA WCMA CMA	Dynamic
11	Env	Target flow rate at environmental flow release or measurement point not delivered as ordered, leading to sub-optimal environmental outcomes.	U	Mod	Low	Monitor flow rate and adjust delivery to meet ordered flow rates. Ongoing communication with the CMA to manage infrastructure or maintenance constraints.	GWMWater GWMWater	Static
12	Safety	Environmental releases create rapid or unexpected changes in flow conditions, resulting in injury to river user[1]	U	Mod	Low	Communicate flow deliveries to communities and key stakeholders and avoid large flows or rapid changes in flow rate during periods of high river use. (e.g. using community SMS stock management updates services). Erect signage where appropriate. Consider safety management around relevant automated structures.	GWMWater/CMA GWMWater/CMA GWMWater	Dynamic

No.	Risk category[1]	Risk description	L[2]	C[3]	Risk rating	Mitigation actions	Lead organisn. for action	Risk type (Static/ Dynamic)
13	Rep	Changing seasonal conditions results in changes to previously announced watering plans, which leads to a loss of community confidence in environmental water management. (Note: These proposed mitigations are also relevant to Risks 12 and 14)	L	Mod	Medium	Ensure community is informed about intended watering objectives and the scenario planning process used. Provide regular local, place-based updates on planned delivery actions and the current/changing situation in river systems leading to changed actions. Undertake broader awareness programs focussing on the importance of e-watering, its complexity and the need for adaptive management.	CMAs CMAs VEWH	Dynamic
14	Rep	Community groups not supportive of environmental watering delivery. Note: risk driven by Lake Lonsdale fish deaths issues in 2020 and reducing lake levels impacting recreational values.	L	Mod	Medium	Engage with the local community through a variety of avenues (e.g. workshops, forums, individually to communicate benefits of environmental watering. Develop state-wide communication products and engage with peak bodies Each organisation to share their intended environmental water related communications plans with all partners. Provide the community with information on the risks and management changes implemented in response to drier conditions. (Note: This risk is still rated as medium after mitigation actions.)	CMA VEWH CMA/VEWH CMA	Dynamic
15	Safety	Negative community sentiment in relation to government decisions/actions creates a safety risk for staff involved in environmental watering actions *This is state wide risk, but may not apply in all systems - the risk rating will reflect local risk levels	U	Mod	Low	Ensure staff are alerted to disgruntled and/or 'potentially or known' physically abusive or aggressive members of the public who may pose a safety risk. Strategic Communication of benefits of environmental water and concern over safety to public (with co-ordination between partners) Ensure safe operational procedures for staff are followed	All	

12. Approval and endorsement

I, the authorised representative of the agency shown below, approve the Seasonal Watering Proposal for the Wimmera system 2022-23.

SIGNED FOR AND ON BEHALF OF Wimmera Catchment Management Authority

Signature of authorised representative

Name of authorised representative:
David Brennan, Chief Executive Officer

Date: 11 April 2022

Mt William Creek at Roses Gap Refuge Pool and PALS Unit, January 2022

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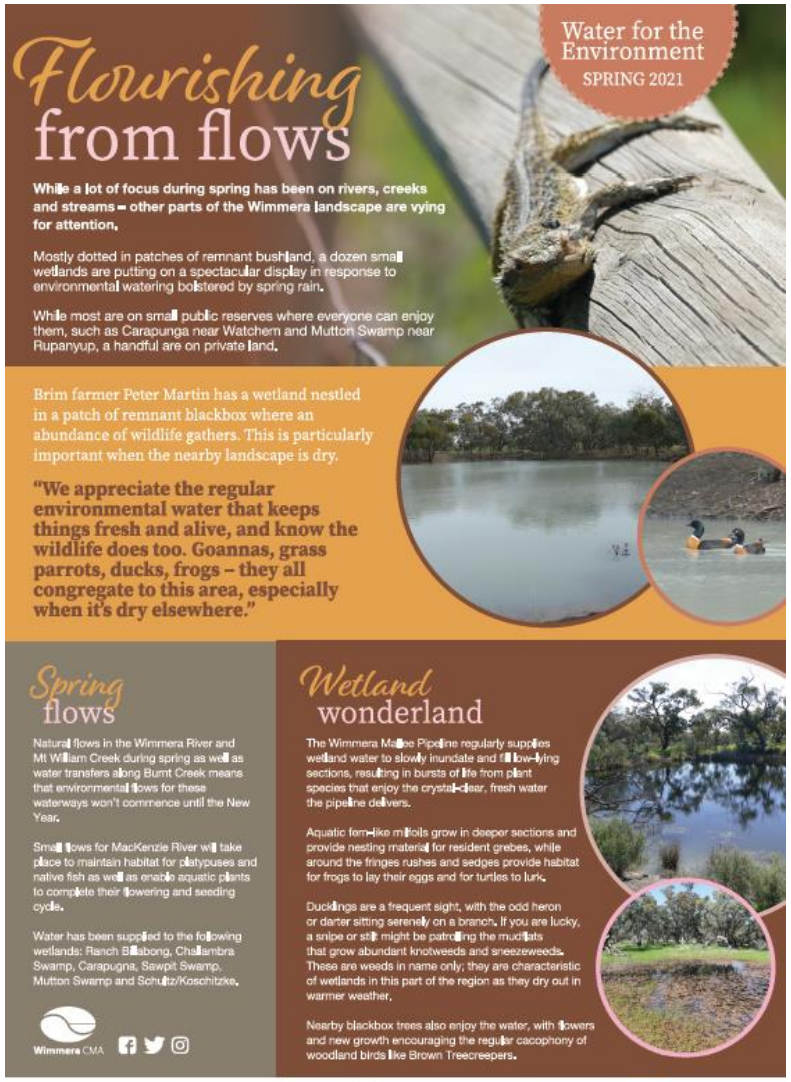
Wimmera CMA staff member, Cobba Harrison teaching Dimboola Memorial Secondary College students about refuge pools on the Wimmera River at Antwerp – March 2022

Gaps cut in grate on Lake Lonsdale Outlet, February 2022 (left), carp mouthing air from surface in low dissolved oxygen conditions on Mt William Creek below Dadswell's Bridge Weir, January 2022 (right).

Appendix 1: Media Information Regarding Environmental Water Releases



Water for the Environment
SPRING 2021

Flourishing from flows

While a lot of focus during spring has been on rivers, creeks and streams – other parts of the Wimmera landscape are vying for attention.

Mostly dotted in patches of remnant bushland, a dozen small wetlands are putting on a spectacular display in response to environmental watering bolstered by spring rain.

While most are on small public reserves where everyone can enjoy them, such as Carapunga near Watchem and Mutton Swamp near Rupanyup, a handful are on private land.

Brim farmer Peter Martin has a wetland nestled in a patch of remnant blackbox where an abundance of wildlife gathers. This is particularly important when the nearby landscape is dry.

"We appreciate the regular environmental water that keeps things fresh and alive, and know the wildlife does too. Goannas, grass parrots, ducks, frogs – they all congregate to this area, especially when it's dry elsewhere."

Spring flows

Natural flows in the Wimmera River and Mt William Creek during spring as well as water transfers along Burnt Creek means that environmental flows for these waterways won't commence until the New Year.

Small flows for MacKenzie River will take place to maintain habitat for platypuses and native fish as well as enable aquatic plants to complete their flowering and seeding cycle.

Water has been supplied to the following wetlands: Ranch Billabong, Challambra Swamp, Carapugna, Sawpit Swamp, Mutton Swamp and Schultz/Koschitzke.

Wimmera CMA

Wetland wonderland

The Wimmera Mallee Pipeline regularly supplies wetland water to slowly inundate and fill low-lying sections, resulting in bursts of life from plant species that enjoy the crystal-clear, fresh water the pipeline delivers.

Aquatic fern-like milfoils grow in deeper sections and provide nesting material for resident grebes, while around the fringes rushes and sedges provide habitat for frogs to lay their eggs and for turtles to lurk.

Ducklings are a frequent sight, with the odd heron or darter sitting serenely on a branch. If you are lucky, a snipe or stilt might be patrolling the mudflats that grow abundant knotweeds and sneezeweeds. These are weeds in name only; they are characteristic of wetlands in this part of the region as they dry out in warmer weather.

Nearby blackbox trees also enjoy the water, with flowers and new growth encouraging the regular cacophony of woodland birds like Brown Treecreepers.

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Water for the Environment
SUMMER 2021

Waterways an ideal summer backdrop

The Wimmera River provides a backdrop to some of the most special moments in people's lives. Proposals, birthday parties, family and wedding photo shoots, first fish, biggest fish, smallest fish, daily walks with the dog, sunrises and sunsets.

It's also a place for adventure where people love to row, paddleboard, run, bike ride, take the tinny out, and fish for species such as Golden Perch, Silver Perch and Freshwater Catfish.

The summer ahead is filled with promise, with the Wimmera River looking nice and healthy thanks to natural flows doing the heavy lifting. Regular rain during late autumn, winter, spring and into summer has kept the river flowing, and coupled with mild weather conditions, fish and other water creatures are thriving.

Check out Explore Wimmera Waterways on film!

What are your plans this summer?
Share your favourite #wimmerawaterways moments via social media – we'd love to see what you get up to!

Explore the Wimmera

Wimmera CMA has been working with local film producer Will Robertson who's been checking out the best waterway spots for the summer holidays.

"The Wimmera River looks picture perfect at the moment. It's great to see so many people out there and making the most of it. Trying your luck with a fishing rod or even going for boat ride. There's something for everyone and I'd recommend getting out there this summer to experience it for yourself."

Wimmera CMA Board, management and staff would like to wish everyone a very special Christmas and New Year, with the hope that families and friends enjoy the festive season.

Wimmera CMA

Summer flows

The recent La Nina prediction may see heavy rainfall in the region, although its impact tends to be more in eastern Victoria. In more dry catchments such as the Wimmera, runoff may be limited. Weather dictates environmental water releases, so the plans for summer flows may change.

Wimmera River: Hot and dry conditions will cause natural flows to cease; environmental flows will commence in the New Year after several weeks of no flow.

MacKenzie River & Burnt Creek: Intermittent flows for these waterways aim to refill refuge pools after periods of no flow, and will last anywhere from several days to weeks, depending on the location.

Mt William Creek: Flows from Lake Lonsdale are planned for late summer to refill refuge pools.

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Appendix 2: Environmental Flow Recommendations

Table A1. Environmental objectives and flow components for the Wimmera River Reaches 2 and 3. Compliance Point – Wimmera River @ Horsham (415200) from Alluvium (2013).

Flow component	Timing	Magnitude	Climatic scenario	Frequency	Duration	Associated environmental objective	Expected watering effects
Cease to Flow	Dec-May	0 ML/d	DROUGHT	As infrequently as possible	Less than 21 days in total	Ensure stress on environmental values is not exacerbated beyond natural. Cease to flow periods should be completed with fresh lasting at least 7 days duration.	Diminishing water levels and water quality (hence upper limit on duration)
			DRY				
			AVERAGE		Less than 7 days in total		
Baseflow	Dec - May	10 ML/d or natural	ALL	Continuous	Continuous	Maintain habitat availability for macroinvertebrates and endemic fish. Maintains riparian vegetation and prevents excessive in stream terrestrial growth.	Maintain edge habitats in deeper pools and runs, and shallow water habitat availability Maintains near permanent inundated stream channel
	June-Nov	100 ML/d	ALL	Continuous	Continuous	Prevent terrestrialisaton of the lower banks from invasive phragmites and provides fish movement and diversity of habitat.	Increased pool depth, flow and variability, including wetting lowest benches.
Freshes	Dec - May	35-40 ML/d	DROUGHT	2 per period	3 - 7 days	Periodically improving water quality for fish and macroinvetebrates	Flushes and mixes small pools during low flows.
			DRY				
	Dec - May	100 ML/d	AVERAGE	2 per period	2 - 7 days	Provide habitat and food for macroinvertebrates, enables fish movement and maintains water quality and diversity of habitat.	Variable flow during low flow season over wood debris increases biofilm abundance as a food source for macronvertebrates), higher flows enables fish movement (increases baseflow depth by approx. 200mm) and flushes and mixes small pools.
			WET	3 per period			
	June - Nov	400 ML/d	DROUGHT	1 per period	1 day	Provides fish movement and to maintain water quality and diversity of habitat for fish and macroinvertebrates.	Increases baseflow depth by approx. 200mm to enable fish passage and and higher shear stresses flushes surface sediments from hard substrates.
			DRY	3 per period	2 days		
			AVERAGE	5 per period	3 days		
			WET	5 per period	4 days		
	June - Nov	1,300 ML/d	DRY	1 per period	1 day	Promotes diversity of habitat for fish, macroinvertebrates and in-channel vegetation.	Wets in-stream benches and entrains organic debris.
			AVERAGE	2 per period	2 days		
			WET	3 per period	3 days		
	June - Nov	2,600 ML/d	AVERAGE	1 per period	2 days	Provides a food source and additional habitat provides additional habitat and wetting of benches for vegetation/ primary production benefits.	Disturbs algae/bacteria/organic biofilm present on rock or wood debris and entrains organic debris.
			WET	2 per period	3 days		

Flow component	Timing	Magnitude	Climatic scenario	Frequency	Duration	Associated environmental objective	Expected watering effects
Bankfull	Any	4,000 ML/d	AVERAGE	1 per period or natural	2 days	Riparian vegetation condition and recruitment. Food sources for macroinvertebrates and primary production. Geomorphic outcomes in terms of maintaining channel size.	Reaches base of riparian vegetation, watering subsoil. Also entrains organic debris and mobilises some sediment/aquatic vegetation.
			WET	1 per period			
Overbank	Aug-Nov	8,000 ML/d	WET	1 per period	1 day	Floodplain vegetation outcomes - maintaining condition of adults and facilitate recruitment. Provides food source for macroinvertebrates and primary production. Maintains floodplain geomorphic features.	Waters floodplain which provides moisture for floodplain vegetation. Entrains organic matter and mobilises sediment and scours instream vegetation.

Table A2. Environmental objectives and flow components for the Wimmera River Reach 4. Compliance Point- Wimmera River @ Lochiel Railway Bridge (415246) from Alluvium (2013)

Flow component	Timing	Magnitude	Climatic scenario	Frequency	Duration	Associated environmental objective	Expected watering effects
Cease to flow	Dec-May	0 ML/d	DROUGHT	As infrequently as possible	Less than 21 days in total	Limits cease to flow to ensure stress on environmental values is not exacerbated beyond the point of return.	Diminishing water levels and water quality (hence upper limit on duration)
			DRY				
			AVERAGE		Less than 7 days in total		
Baseflow	Dec-May	15 ML/d or natural	ALL	Continuous	Continuous	Maintain habitat availability for macroinvertebrates and endemic fish. Maintains riparian vegetation and prevents excessive in stream terrestrial growth.	Maintain edge habitats in deeper pools and runs, and shallow water habitat availability Maintains near permanent inundated stream channel (>1.5m deep pools)
	Jun-Nov	30 ML/d	ALL	Continuous	Continuous	Provide additional habitats for fish and macroinvertebrates	Increases depth by 8-18 cm over summer baseflows
Freshes	Dec - May	70 ML/d	DROUGHT	1 per period	2-7days	Provide habitat and food for macroinvertebrates, enables fish movement and maintains water quality and diversity of habitat.	Variable flow during low flow season over wood debris increases biofilm abundance as a food source for macronvertebrates), higher flows enables fish movement (increases baseflow depth by approx. 11-25cm) and flushes and mixes small pools.
			DRY	2 per period			
			AVERAGE				
			WET	3 per period			
	June - Nov	70 ML/d	DROUGHT	1 per period	1 day	Provide habitat and food for macroinvertebrates, enables fish movement and maintains water quality and diversity of habitat.	Variable flow during low flow season over wood debris increases biofilm abundance as a food source for macronvertebrates), higher flows enables fish movement (increases baseflow depth by approx. 16-22 cm) and flushes and mixes small pools.
			DRY	3 per period	2 days		
			AVERAGE	5 per period	3 days		
			WET	5 per period	4 days		
	June - Nov	200 ML/d	DRY	1 per period	1 day	Provides fish movement and to maintain water quality and diversity of habitat for fish and macroinvertebrates.	Inundates low benches and increases edge coverage.
			AVERAGE	2 per period	2 days		
			WET	3 per period	3 days		

Flow component	Timing	Magnitude	Climatic scenario	Frequency	Duration	Associated environmental objective	Expected watering effects
	June - Nov	1300 ML/d	AVERAGE	1 per period	2 days	Provides a food source and additional habitat provides additional habitat and wetting of benches for vegetation/ primary production benefits.	Disturbs algae/bacteria/organic biofilm present on rock or wood debris and entrains organic debris. Flushes surface substrates and inundates benches.
			WET	2 per period	3 days		
Bankfull	Any	2,000 ML/d	AVERAGE	1 per period, or natural	2 days	Riparian vegetation condition and recruitment. Food sources for macroinvertebrates and primary production. Geomorphic outcomes in terms of maintaining channel size.	Reaches base of riparian vegetation, watering subsoil. Also entrains organic debris and mobilises some sediment/aquatic vegetation.
			WET	1 per period			
Overbank	Aug-Nov	6,000 ML/d	WET	1 per period or natural	1day	Floodplain vegetation outcomes - maintaining condition of adults and facilitate recruitment. Provides food source for macroinvertebrates and primary production. Maintains floodplain geomorphic features.	Waters floodplain which provides moisture for floodplain vegetation. Entrains organic matter and mobilises sediment and scours instream vegetation.

Table A3. Environmental objectives and flow components for MacKenzie River Reach 1 and 2. Compliance Point: Not present, from Alluvium (2013)

Flow component	Timing	Magnitude	Climatic scenario	Frequency	Duration	Associated environmental objective	Expected watering effects
Cease to Flow	Dec - May	0 ML/d	DROUGHT	As infrequently as possible	Less than 80 days in total	Limits cease to flow to ensure stress on environmental values is not exacerbated beyond the point of return.	Diminishing water levels and water quality (hence upper limit on duration). Disconnects pools.
			DRY		Less than 30 days in total		
			AVERAGE				
Baseflow	Dec - May	2 ML/d or natural	ALL	Continuous	Continuous	Maintain habitat availability for macroinvertebrates and endemic fish. Maintains riparian vegetation and prevents excessive in stream terrestrial growth.	Maintain edge habitats in deeper pools (0.5 – 2m) and runs, and shallow water habitat availability. Maintains near permanent inundated stream channel.
	June - Nov	27 ML/d	ALL	Continuous	Continuous	Facilitates dispersal of juvenile platypuses along the river and into the Wimmera River	Intended to create a depth >50cm over riffles
Freshes	Dec - May	5 ML/d	DROUGHT	3 per period	4-7 days	Prevent water quality decline that impacts on macroinvertebrates and fish	Flushes pools
			DRY	4 per period	4-7 days		
	Dec - May	50 ML/d	AVERAGE	2 per period	2-7 days	Enhances food and habitat sources for macroinvertebrates, creates additional habitat, enhances water quality and enables fish movement.	Provides flows over wood debris to increase biofilm abundance as a food source, higher flow also facilitates fish movement with deeper flows over riffles, flushes pools for water quality outcomes and engages higher on pool/riffle margins, creating additional habitat.
			WET	3 per period	2-7 days		
	June-Nov	55 ML/d	DROUGHT	5 per period	2 days	Provides habitat outcomes for macroinvertebrates	Flush surface sediments from hard substrates through increased shear stress.
			DRY	5 per period	4 days		

Flow component	Timing	Magnitude	Climatic scenario	Frequency	Duration	Associated environmental objective	Expected watering effects
			AVERAGE	5 per period	5 days		
			WET	5 per period	7 days		
	June-Nov	130 ML/d	DROUGHT	1 per period	1 days	Stumluate fish movement and provide flow variability to maintain water quality and diversity of fish habitats.	Increase the baseflow water depth.
			DRY	3 per period	2 days		
			AVERAGE	5 per period	3 days		
			WET	5 per period	4 days		
Bankfull	Any	500 ML/d	AVERAGE	1 per period	2 days	Riparian vegetation condition and recruitment. Food sources for macroinvertebrates and primary production. Geomorphic outcomes in terms of maintaining channel size.	Reaches base of riparian vegetation, watering subsoil. Also entrains organic debris and mobilises some sediment/aquatic vegetation.
			WET	1 per period	2 days		
Overbank	Aug-Nov	900 ML/d	WET	1 per period	1 day	Floodplain vegetation outcomes - maintaining condition of adults and facilitate recruitment. Provides food source for macroinvertebrates and primary production. Maintains floodplain geomorphic features.	Waters floodplain which provides moisture for floodplain vegetation. Entrains organic matter and mobilises sediment and scours instream vegetation.

Table A4. Environmental objectives and flow components for MacKenzie River Reach 3. Compliance Point: MacKenzie River @ McKenzie Creek Reserve (415251) from Alluvium 2013.

Flow component	Timing	Magnitude	Climatic scenario	Frequency	Duration	Associated environmental objective	Expected watering effects
Cease to Flow	Dec-May	0 ML/d	DROUGHT	As infrequently as possible	Less than 80 days in total	Limits cease to flow to ensure stress on environmental values is not exacerbated beyond the point of return.	Diminishing water levels and water quality (hence upper limit on duration). Disconnects pools.
			DRY		Less than 30 days in total		
			AVERAGE				
Baseflow	Any	10ML/d or natural	ALL	Continuous	Continuous	Maintain habitat availability for macroinvertebrates and endemic fish. Maintains riparian vegetation and prevents excessive in stream terrestrial growth.	Riffles have >10cm inundation, also widens bed coverage and inundates edges at pools.
Freshes	Dec - May	35 ML/d	DROUGHT	3 per period	2-7 days	Enhances food and habitat sources for macroinvertebrates, creates additional habitat, enhances water quality and enables fish movement.	Provides flows over wood debris to increase biofilm abundance as a food source, higher flow (approx. 200mm) also facilitates fish movement with deeper flows over riffles, flushes pools for water quality outcomes and engages higher on pool/riffle margins, creating additional habitat.
			DRY	3 per period	3-7 days		
			AVERAGE	4 per period	3-7 days		
			WET	4 per period	3-7 days		
	Jun-Nov	35ML/d	DROUGHT	5 per period	2 days	Enhances fish communities by stimulating movementand maintains water quality and diversity of habitat.	Increases depth by approx.. 200mm which will enable fish to more easily move between pools.
			DRY		4 days		
			AVERAGE		5 days		

Flow component	Timing	Magnitude	Climatic scenario	Frequency	Duration	Associated environmental objective	Expected watering effects
			WET		7 days		
	Jun-Nov	190 ML/d	AVERAGE	1 per period	1 day	Provides habitat outcomes for macroinvertebrates	Flush surface sediments from hard substrates through increased shear stress.
			WET		2 days		
Bankfull	Any	500 ML/d	WET	1 per period, or natural	1-day	Riparian vegetation condition and recruitment (including Callistemon Wimmensis). Food sources for macroinvertebrates and primary production. Geomorphic outcomes in terms of maintaining channel size.	Reaches base of riparian vegetation, watering subsoil. Also entrains organic debris and mobilises some sediment/aquatic vegetation.
Overbank	Aug-Nov	1000 ML/d	WET	1 per period, or natural	1 day	Floodplain vegetation outcomes - maintaining condition of adults and facilitate recruitment (including Callistemon Wimmerensis). Provides food source for macroinvertebrates and primary production. Maintains floodplain geomorphic features.	Waters floodplain which provides moisture for floodplain vegetation. Entrains organic matter and mobilises sediment and scours instream vegetation.

Table A5. Environmental objectives and flow components for Lower Mt William Creek (below Lake Lonsdale). Compliance Point: Mt William Creek at Lake Lonsdale Tail gauge (415203) from Alluvium 2013.

Flow component	Timing	Magnitude	Climatic scenario	Frequency	Duration	Associated environmental objective	Expected watering effects
Cease to Flow	Dec - May	0 ML/d	DROUGHT	As infrequently as possible	Less than 90 days in total	Limits cease to flow to ensure stress on environmental values is not exacerbated beyond the point of return.	Diminishing water levels and water quality (hence upper limit on duration). Disconnects pools.
			DRY		Less than 30 days in total		
			AVERAGE				
Baseflow	Any	5 ML/d or natural	All	Continuous	Continuous	Maintain habitat availability for macroinvertebrates and endemic fish. Maintains riparian vegetation and prevents excessive in stream terrestrial growth.	Creates near-permanent inundated stream channel and shallow water habitat as well as inundating edges at pools.
Freshes	Dec-May	20 ML/d	DROUGHT	3 per period	2-7 days	Maintain water quality for fish and macroinvertebrates	Flushes small pools
			DRY	3 per period	4-7 days		
	Dec - May	30 ML/d	AVERAGE	3 per period	2-7 days	Enhances food and habitat sources for macroinvertebrates, creates additional habitat, enhances water quality and enables fish movement.	Increases flow depths from baseflow by 16-19 cm and inundates benches
			WET	3 per period	3-7 days		
		100 ML/d	DROUGHT	1 per period	3 days		

Flow component	Timing	Magnitude	Climatic scenario	Frequency	Duration	Associated environmental objective	Expected watering effects
	June-Nov		DRY	3 per period	3 days	Enhances food and habitat sources for macroinvertebrates.	Inundates benches (number of benches wetted depends on this size of the fresh) and entrains organic material as well as flushing surface sediments from hard substrates.
			AVERAGE	3 per period	5 days		
			WET	5 per period	7 days		
	Jun-Nov	500 ML/d	DRY	1 per period	1 days		
			AVERAGE	2 per period	2 days		
			WET	3 per period	2 days		
Bankfull	Any	750 ML/d	AVERAGE	1 per year or natural	2 days	Riparian vegetation condition and recruitment. Food sources for macroinvertebrates and primary production. Geomorphic outcomes in terms of maintaining channel size.	Reaches base of riparian vegetation, watering subsoil. Also entrains organic debris and mobilises some sediment/aquatic vegetation.
			WET	1 per year	4 days		
Overbank	Aug - Nov	1,500 ML/d	WET	1 per year	1 day	Floodplain vegetation outcomes - maintaining condition of adults and facilitate recruitment. Provides food source for macroinvertebrates and primary production. Maintains floodplain geomorphic features.	Waters floodplain which provides moisture for floodplain vegetation. Entrains organic matter and mobilises sediment and scours instream vegetation.

Table A6. Environmental objectives and flow components for Upper Mt William Creek (above Lake Lonsdale). Compliance Point: Mt William Creek @ Mokepilly (415252) from SKM (2005)

Flow component	Timing	Magnitude	Climatic scenario	Duration	Associated environmental objective	Expected watering effects
Cease to Flow	Dec-May	0 ML/d	1 per period	90 days maximum	increase in macroinvertebrate species diversity.	Provides a physical disturbance to the exposed river channel.
Baseflow	June-Nov	Minimum 24 ML/d	Continuous	Continuous	Conditions suitable to sustain native fish and macroinvertebrates.	Increases water quality and habitat in pools.
Freshes	Dec – May	> 1 ML/d	2 per year	5 days	Assists in maintaining and access to suitable habitat for macroinvertebrate and fish species. Triggers spawning in many Western Carp Gudgeon as well as a number of other key native fish species.	Prevents sediment accumulation that can smother habitat. Assists in maintenance of wetted channel during summer low flow period and improves water quality in pools.
	June-November	>52 ML/d	4 per year	7 days	Provides disturbance to macroinvertebrate communities which increases abundance and diversity in native fish species and triggers spawning in Western Carp Gudgeon. Improves water quality in pools.	Flushes small pools to improve water quality and opens up benthic habitat.
	Winter-Spring	>500 ML/d	2 per year	2 days	Maintains instream/riparian//terrestrial vegetation dynamics and geomorphic character as well as habitat for macroinvertebrates.	Transports sediment downstream to prevent the smothering of key habitats. Flushes fine sediment and organic material from pools. Disturbs terrestrial vegetation on bank.

Table A7. Environmental objectives and flow components for Bungalally Creek. Compliance Point: Not Present, from Alluvium (2013).

Flow component	Timing	Magnitude	Climatic scenario	Frequency	Duration	Associated environmental objective	Expected watering effects
Bankfull	Any	60 ML/d	AVERAGE WET	1 per period or natural	2 days	Maintain condition and facilitate recruitment or riparian vegetation. Maintain structural integrity of channel.	Flows will reach high on the bank, providing moisture to subsoil and drowning terrestrial species.
Overbank	Aug-Nov	150 ML./d	WET	1 per period or natural	1 days	Maintain condition and facilitate recruitment of floodplain vegetation. Maintains floodplain geomorphic features.	Flows will reach high on the bank, providing moisture to subsoil and drowning terrestrial species. It will also mobilise fine sediments.

Table A8. Environmental objectives and flow components for Burnt Creek Reach 1 (upper Burnt Creek). Compliance Point: Burnt Creek at Wonwondah East (415223), from Alluvium (2013)

Flow component	Timing	Magnitude	Climatic scenario	Frequency	Duration	Associated environmental objective	Expected watering effects
Cease to Flow	Dec-May	0 ML/d	DROUGHT DRY AVERAGE	As infrequently as possible	Less than 80 days in total Less than 30 days in total	Limits cease to flow to ensure stress on environmental values is not exacerbated beyond the point of return.	Diminishing water levels and water quality (hence upper limit on duration). Disconnects pools.
Baseflow	All year	1 ML/d or natural	ALL	Continuous	Continuous	Maintain habitat availability for macroinvertebrates and endemic fish. Maintains riparian vegetation and prevents excessive in stream terrestrial growth.	Provides bed coverage and inundates edges at pools.
Freshes	Dec - May	30 ML/d	DROUGHT	3 per period	2-7 days	Prevent water quality decline for macroinvertebrate and fish populations	Flushes pools during low flows.
			DRY	3 per period	4-7 days		
			AVERAGE	3 per period	2-7 days		
			WET	3 per period	3-7 days		
	Jun-Nov	55 ML/d	DROUGHT	1 per period	3 days	Provides improved habitat for fish and macroinvertebrates.	Flushes surface sediments from hard substrates for macroinvertebrates via increased shear stress. Also increases depths by approx.. 200mm.
			DRY	3 per period	3 days		
			AVERAGE	5 per period	5 days		
			WET	5 per period	7 days		
	May - Jun	160 ML/d	DRY	1 per period	1 day	Support macroinvertebrate communities through increased food/habitat availability.	Velocities are sufficient to disturb the algae/bacteria/organic biofilm present on rock or wood debris.
			AVERAGE	2 per period	2 days		
			WET	3 per period	3 days		
Bankfull	Any	400 ML/d	AVERAGE	1 per period, or natural	2 days	Riparian vegetation condition and recruitment. Food sources for macroinvertebrates and primary	Reaches base of riparian vegetation, watering subsoil. Also entrains organic

Flow component	Timing	Magnitude	Climatic scenario	Frequency	Duration	Associated environmental objective	Expected watering effects
			WET			production. Geomorphic outcomes in terms of maintaining channel size.	debris and mobilises some sediment/aquatic vegetation.
Overbank	Aug-Nov	1,000 ML/d	WET	1 per year	1 day	Floodplain vegetation outcomes - maintaining condition of adults and facilitate recruitment. Provides food source for macroinvertebrates and primary production. Maintains floodplain geomorphic features.	Waters floodplain which provides moisture for floodplain vegetation. Entrains organic matter and mobilises sediment and scours instream vegetation.

Table A9. Environmental objectives and flow components for Burnt Creek Reach 2 (lower Burnt Creek). Compliance Point: Not Present, from Alluvium (2013).

Flow component	Timing	Magnitude	Climatic scenario	Frequency	Duration	Associated environmental objective	Expected watering effects.
Bankfull	Any	45 ML/d or natural	AVERAGE WET	1 per period, or natural	2 days	Riparian vegetation condition and recruitment. Food sources for macroinvertebrates and primary production. Geomorphic outcomes in terms of maintaining channel size.	Reaches base of riparian vegetation, watering subsoil. Also entrains organic debris and mobilises some sediment/aquatic vegetation.
Overbank	Aug - Nov	90 ML/d	WET	1 per period	1 day	Floodplain vegetation outcomes - maintaining condition of adults and facilitate recruitment. Provides food source for macroinvertebrates and primary production. Maintains floodplain geomorphic features.	Waters floodplain which provides moisture for floodplain vegetation. Entrains organic matter and mobilises sediment and scours instream vegetation.

Table A10. Environmental objectives and flow components for Dock Lake Compliance Point: Not Present, from Jacobs (2015)

Flow component	Timing	Magnitude	Climatic scenario	Frequency	Duration	Associated environmental objective	Expected watering effects
Inundation (partial fill)	Any	Between 271 ML and 973 ML	DRY/AVERAGE/WET	1 in 2 years (WET) 1 in 3-4 years (AVE) 1 in 5 years (DRY)	3 to 14 months	Wetland vegetation and bird life cycles with ancillary benefits for frogs, macroinvertebrates and turtles	Provide shallow water inundation to enable nesting habitat and food sources for waterbirds and other fauna species. Drowns terrestrial annual grasses and supports growth of wetland herbs.

Appendix 3: Flow components that have been delivered from 2005 to 2022.

Reach	Flow Component	Hydrological achievement of flow components over time														
		07-08	08-09	09-10	10-11	11-12	12-13	13-14	14-15	15-16	16-17	17-18	18-19	19-20	20-21	21-22
4 Wimmera River	Summer-autumn baseflows 15 ML/d	E/U	E/U	E/U	E/U	E/U	E/U	E/U	E/U	E	E	E	E	E	E	E

Reach	Flow Component	Hydrological achievement of flow components over time														
		07-08	08-09	09-10	10-11	11-12	12-13	13-14	14-15	15-16	16-17	17-18	18-19	19-20	20-21	21-22
4 Wimmera River	Winter-spring baseflows 30 ML/d	U	U	U	E/U	E/U	E/U	E/U	E/U	U	U	E/U	E	U		U
4 Wimmera River	Summer-autumn freshes 70 ML/d x 1-3 x 2-7 d	E/U	E/U	E/U	E/U	E/U	E/U	E/U	E/U	E	E	E	E		U	E/U
4 Wimmera River	Winter-spring freshes 70 ML/d x 1-5 x 1-4 d	U	U	U	E/U	E/U	E/U	E/U	E/U	U	U	U/E	E	U	U	U
2 MacKenzie River	Summer autumn, baseflows 2 ML/d	E/U/O	E/U/O	E/U/O	E/U/O	E/U/O	E/U/O	E/U/O	E/U/O	E/O	E	E	E	E	E	E
2 MacKenzie River	Winter spring baseflows 27 ML/d	U	U	U	E/U/O	E/U/O	E/U/O	E/U/O	E/U/O	U/O	U	U/E	E	U	U	U
2 MacKenzie River	Summer-autumn freshes 5 to 50 ML/d x 2-4 x 2-7 d	E/U	E/U	E/U	E/U	E/U	E/U	E/U	E/U	E	E	E	E	E	E	E
2 MacKenzie River	Winter-spring freshes 55 ML/d x 5 x 2-7d	U	U	U	E/U	E/U	E/U	E/U	E/U	U	U	U/E	E	U	U	U
2 MacKenzie River	Winter-spring freshes 130 ML x 1-5 x 1-4 d	U	U	U	E/U	E/U	E/U	E/U	E/U	U	U	U				U
3 MacKenzie River	Summer, autumn, Winter, spring baseflows 10 ML/d	E/U	E/U	E/U	E/U	E/U	E/U	E/U	E/U		U/E	E/U	E			
3 MacKenzie River	Summer-autumn freshes 35 ML/d x 3-4 x 2-7 d	U	U	U	E/U	E/U	E/U	E/U	E/U		E	E	E			
3 MacKenzie River	Winter-spring freshes 35 ML/d x 5 x 2-7 d	U	U	U	E/U	E/U	E/U	E/U	E/U		U	U	U/E			
Lower Mt William	Summer, autumn, Winter, spring baseflows 5 ML/d	E/U	E/U	E/U	E/U	E/U	E/U	E/U	E/U	U	E/U	E	E	E		O/E/U
Lower Mt William	Summer-autumn freshes 20-30 ML x 3 x 2-7 d	E/U	E/U	E/U	E/U	E/U	E/U	E/U	E/U		E	E	E	E	E	E
Lower Mt William	Winter-spring freshes 100-500 ML/d x 1-5 x 1-7d	E/U	E/U	E/U	E/U	E/U	E/U	E/U	E/U		U	U		E		
Upper Mt William Creek	Summer-autumn baseflows 150 ML/total	U	U	U	U/E	U/E	U/E	U/E	E/U	E/U	U	U	E	E		
Upper Burnt Creek	Summer-autumn Winter-spring baseflows 1 ML/d	E/U/O	E/U/O	E/U/O	E/U/O	E/U/O	E/U/O	E/U/O	E/U/O	E/O/U	E/U/O	E/U/O	E/U/O	E/U/O	E/U/O	E/O/U

Reach	Flow Component	Hydrological achievement of flow components over time														
		07-08	08-09	09-10	10-11	11-12	12-13	13-14	14-15	15-16	16-17	17-18	18-19	19-20	20-21	21-22
Upper Burnt Creek	Summer-autumn freshes 30 ML/d x 3 x 2-7d	E/U	E/U	E/U	E/U	E/U	E/U	E/U	E/U	E	E	E	E			
Upper Burnt Creek	Winter-spring freshes 55 ML/d x 1-5 x 3-7d	U	U	U	U	U/E	E/U	E/U	E/U	O/U	U/O	U/O	U/O	U/O	U/O	U/O
Upper Burnt Creek	Autumn-winter freshes 160 ML/d x 1-3 x 1-3d	U	U	U	U	U/E	U	U	U	O/U	U	U				U
Lower Burnt Creek	Winter-spring freshes 45ML/d x1 x 2d	U	U	U	U	U	E/U	E/U	E/U		U	U				
Bungalally Creek	Winter-spring freshes 60 ML/d x 1 x 2d	U	U	U	U	U	E/U	E/U	E		U	U				

Key for Table

	No significant part of the flow component achieved
	Flow component partially achieved
	Flow component has been completely achieved, i.e. complete duration, frequency and magnitude was achieved

E	Managed environmental water release
O	Consumptive water en route/other managed flow
U	Unregulated flows
X	Unknown

Appendix 4: Priority Watering Actions

Table A11. Priority Watering Actions Wimmera Reach 4.

PWA Target	Flow function	Priority	Rationale	Volume (ML)
Baseflow Dec-May 15 ML/day	Maintain edge habitats in deeper pools and runs, and shallow water habitat availability for macroinvertebrates and endemic fish. Maintains near-permanent inundated stream channel for riparian vegetation and to prevent excessive in stream terrestrial species growth.	Very High	Salinity levels in the lower Wimmera River reach 50,000 µS/cm during cease to flow conditions. This flow component plays a critical role in maintaining water quality for aquatic and riparian ecosystems. This flow mitigates severe salinity impacts so reduces likelihood of fish kills, algae blooms and die back of fringing vegetation and macroinvertebrates which were common events during the 2002 to 2010 when there were long cease to flow periods. This baseflow also supports vegetation in low benches.	9,100 ML
Baseflow June-Nov 30 ML/day	Provides flow variability to maintain diversity of habitats.	Very High	It is of high importance to maintain constant baseflows in the lower Wimmera River during winter and spring when there are periods of low rainfall. Salinity levels in the lower Wimmera River reach 50,000 uS/cm during cease to flow conditions. This flow component plays a critical role in maintaining water quality for aquatic and riparian ecosystems. This flows diminish the high risk of die back of vegetation and fish fills which were common events during the 2002 to 2010 when there were long cease to flow periods.	10,980 ML
Freshes Dec-May, 1-3 events of 70 ML/day 2-7 days	Prevent water quality decline by flushing pools during low flows. Provide variable flow during low flow season for macroinvertebrates (over wood debris to increase biofilm abundance as a food source), fish movement and to maintain water quality and diversity of habitat.	Very High	Salinity levels in the lower Wimmera River reach 50,000 uS/cm during cease to flow conditions. This flow component plays a critical role in freshening the water quality during very hot period of the year where evaporation and seepage levels are high and baseflows are not able to prevent water quality decline in refuge pools. These freshes maintain water quality for aquatic and riparian ecosystems. These freshes diminish the high risk of algal blooms, die back of vegetation and fish fills which were common events during the 2002 to 2010 when there were long cease to flow periods.	150 – 1575 ML
Freshes - smaller June-Nov 1-5 events of 70 ML/day 1-4 days	Increase the baseflow water depth by to provide stimulus for fish movement (not required in drought years, frequently required in wet years). Provide flow variability to maintain water quality and diversity of fish habitats. Wets lower benches, entraining organic debris and promoting diversity of habitat.	Very High	This flow component plays a critical role in freshening the water quality during winter and spring periods when there is low rainfall. These freshes are useful when baseflows are not able to prevent water quality decline. These freshes provide flow variability to stimulate fish movement and maintain a healthy water quality for aquatic and riparian ecosystems.	60 – 1200 ML
Freshes - medium June-Nov 1-3 events of 200 ML/day 1-3 days	Provide variable flow during high flow season for fish movement and to maintain water quality and diversity of habitat. Also flushes surface sediments from hard substrates for macroinvertebrates	Medium	Wet lower benches, entraining organic debris and promoting diversity of habitat	130 – 1170 ML

PWA Target	Flow function	Priority	Rationale	Volume (ML)
Inundation of Ranch Billabong	Provide water to disconnected anabranch of Wimmera River at Dimboola via pumping	High	Provides cultural outcomes given the significance of the site and also some riparian and aquatic vegetation outcomes (e.g. Common Sneezeweed).	20 ML

Table 12. Priority Watering Actions MacKenzie River Reach 3.

PWA Target	Flow function	Priority	Rationale	Volume (ML)
Baseflow all year 10 ML/day	Maintain edge habitats and shallow water habitat availability for macroinvertebrates and endemic fish and near-permanent inundated stream channel for riparian vegetation and prevents excessive instream terrestrial species growth. Facilitate annual dispersal of juvenile platypus into the Wimmera River.	High (Very High June-November)	Prevents reach 2 and reach 3 from drying out completely and loss of high value fish and platypus communities. Lack of flows would see it dry out in a few weeks thereby losing a high value fish community and opportunities for fish movement/dispersal.	8210 ML
Freshes December-May 3-4 events of 35 ML/day 2-7 days	Provide variable flow during low flow season for macroinvertebrates (over wood debris to increase biofilm abundance as a food source), fish movement and to maintain water quality and diversity of habitat.	High	This watering action benefits native fish movement and macroinvertebrate heath and maintenance of water quality and dispersal of the very high value platypus population.	300 – 1400 ML
Freshes June-November 5 events of 35 ML/day 2-7 days	Stimulate fish movement and maintain water quality and diversity of habitat.	Very High	This watering action benefits native fish movement and macroinvertebrate heath and maintenance of water quality and diversity of habitat.	350 – 1225 ML

Table 13. Priority Watering Actions MacKenzie River Reach 2.

PWA Target	Flow function	Priority	Rationale	Volume (ML)
Baseflow Dec-May 2 ML/day	Maintain edge habitats in deeper pools and runs, and shallow water habitat availability for macroinvertebrates and endemic fish. Maintains near-permanent inundated stream channel to prevent excessive in stream terrestrial species growth.	Very High	This reach of Mackenzie River supports the source population of indigenous fish (River Blackfish, Mountain Galaxias, Flathead Gudgeon, Southern Pygmy Perch) and a population of platypus that are regionally important. This watering action prevents this reach from drying out completely and loss of high value fish and platypus communities.	950 ML

PWA Target	Flow function	Priority	Rationale	Volume (ML)
Baseflow June-Nov 27 ML/day	Facilitate annual dispersal of juvenile platypus into the Wimmera River. Provides flow variability to maintain diversity of habitat.	High	Whilst these flows are typically generated through pickup, if it is a dry winter spring there's still a risk that it could dry out in parts.	5,490 ML
Freshes Dec-May 2-4 events of 5-50 ML/day 2-7 days	Prevent water quality decline by flushing pools during low flows. Provide variable flow during low flow season for macroinvertebrates (over wood debris to increase biofilm abundance as a food source), fish movement and to maintain water quality and diversity of habitat.	Very High	Fresh volume varies from drought/dry (5 ML/day) to average/wet (50 ML/day). Smallish volume for drought/dry has typically meant it has been delivered with baseflows to get the full suite of flow for the reach. This watering action prevents water quality decline (dissolved oxygen) and supports fish movement (especially the higher fresh). This watering action is also important for vegetation diversity on banks.	120 – 1260 ML
Freshes June-Nov 5 events of 55 ML/day 2-7 days	Provide variable flow during low flow season for macroinvertebrates (over wood debris to increase biofilm abundance as a food source), fish movement and to maintain water quality and diversity of habitat. Flush surface sediments from hard substrates to support macroinvertebrates.	High	Provides some variation of flow to encourage fish movement, healthy macroinvertebrate communities, maintains water quality and mobilisation of sediment.	250 - 875 ML

Table 28. Priority Watering Actions Upper Burnt Creek.

PWA Target	Flow function	Priority	Rational	Volume (ML)
Baseflow all year 1 ML/day	Maintain edge habitats and shallow water habitat availability for fish and macroinvertebrates and inundated stream channel for riparian vegetation and prevents excessive instream terrestrial growth.	Very High	This watering action is critical for supporting a good native fish community as well as Western Swamp Crayfish.	1,825 ML
Fresh Dec-May 3 events of 30 ML/day 2-7 days	Prevent water quality decline by flushing pools during low flows	Very High	This watering action provides good vegetation, macroinvertebrates and native fish outcomes.	270 - 945 ML
Fresh Jun-Nov 1-5 events of 55 ML/day 3-7 days	Provide variable flow for fish movement and diversity of habitat. Also flushes surface sediments from hard substrates for macroinvertebrates. Disturb the algae/bacteria/organic biofilm present on rock or wood debris to support macroinvertebrate communities.	Very High	This watering action provides good vegetation, macroinvertebrates and native fish outcomes.	180 – 2100 ML

PWA Target	Flow function	Priority	Rational	Volume (ML)
Fresh May-Jun 1-3 events of 160 ML/day 1-3 days	Disturb the algae/bacteria/organic biofilm present on rock or wood debris to support macroinvertebrate communities.	Medium	This watering action provides good vegetation, macroinvertebrates and native fish outcomes.	160 - 1440 ML

Table 15. Priority Watering Actions Lower Burnt Creek.

PWA Target	Flow function	Priority	Rational	Volume (ML)
Bankfull Any month 1 event of 45 ML/d for 2 days	Inundate riparian vegetation to maintain condition and facilitate recruitment. Entrain organic debris in the channel to support macroinvertebrates. Maintain structural integrity of channel.	High	This watering action is critical for supporting a good fish community as well as Western Swamp Crayfish.	300 ML
Overbank Aug-Nov 1 event of 90 ML/d for 1 day	Inundate floodplain vegetation to maintain condition and facilitate recruitment. Entrain organic debris from the floodplain to support macroinvertebrates. Maintains floodplain geomorphic features.	Medium	This watering action provides good vegetation, macroinvertebrates and native fish outcomes.	180 ML

Table 16. Priority Watering Actions Bungalally Creek.

PWA Target	Flow function	Priority	Rationale	Volume (ML)
Bankfull Any time of year 1 event of 60 ML/day for 2 days	Inundate riparian zone to maintain condition of adults and facilitate recruitment for riparian EVCs Maintain structural integrity of channel and prevents loss of channel diversity through lack of flow variability.	Medium	Bungalally Creek has valuable riparian vegetation in some sections which provides important habitat for terrestrial and aquatic species and much like Reach 2 of the Burnt Creek. Due to the high level regulation of this system and the fact that it would only receive flows during high flow events, the creek bed will most probably be completely dry when watering commences.	300 ML

Table 17. Priority Watering Actions Upper Mt William Creek.

PWA Target	Flow function	Priority	Rationale	Volume (ML)
Fill refuge pools during dry conditions (summer/ autumn)	Prevents sediment accumulation that can smother habitat. Assists in maintaining and access to suitable habitat for macroinvertebrate and fish species. Assists in maintenance of wetted channel during summer low flow period and improves water quality in pools. Triggers spawning in many Western Carp Gudgeon as well as a number of other key native fish species.	Very High	Lake Lonsdale levels are reducing following dry conditions in 2017. It is very important to continue to monitor these refuge pools that provide crucial drought refuge to high value native fish populations, Obscure Galaxias, Australian Smelt, Flathead Gudgeon, short finned eel (rarely) and the 'vulnerable' Southern Pygmy Perch, (Biosis 2012), (SKM 2005).	300 ML

Table 18. Priority Watering Actions Lower Mt William Creek.

PWA Target	Flow function	Priority	Rationale	Volume
Baseflow year round 5 ML/day	Maintain edge habitats and shallow water habitat availability for macroinvertebrates and endemic fish and near-permanent inundated stream channel for riparian vegetation and prevents excessive instream terrestrial species growth.	High	The lower Mt William Creek contains high value native fish populations, River Blackfish, Mountain Galaxias, Australian Smelt, Flat-headed Gudgeon, short finned eel and the 'vulnerable' Southern Pygmy Perch, (Austral 2015). The absence of flow would place these very high environmental values at risk. River Blackfish have been increasingly rare in the sections of the Wimmera catchment outside the Grampians (EnviroDNA 2017a, 2017b).	1,825 ML
Fresh Dec-May 3 events of 20 to 30 ML/day 2-7 days	Prevent water quality decline by flushing pools during low flows. Provide variable flow during low flow season for macroinvertebrates (over wood debris to increase biofilm abundance as a food source), fish movement and to maintain water quality and diversity of habitat.	Very High	This watering action provides a much needed improvement to water quality with a pulse of water reaching the end of the creek which baseflows tend not to be able to do. The higher fresh will inundate benches and overtop woody debris.	90 - 525 ML
Fresh June-Nov 1-5 events of 100 ML/day 1-7 days	Wets benches, entraining organic debris and promoting diversity of habitat. Flush surface sediments from hard substrates to support macroinvertebrates. Wets low benches, entraining organic debris and promoting diversity of habitat.	Medium	If flow for the Wimmera River is provided from Taylors Lake then these freshes are important to water the Wimmera River above Taylors. This watering action also provides a dispersal mechanism for high value native fish communities as well as vegetation and macroinvertebrate outcomes.	285 - 3325 ML

Table 19. Priority Watering Actions Dock Lake

PWA Target	Flow function	Priority	Rationale	Volume (ML)
Provide low-level inundation for high quality wetland habitat	Provides abundant vegetation response and subsequent bird-breeding events for a number of wetland bird species.	High	Aligns with objectives and recommendations in *Dock Lake FLOWS Study* (Jacobs, 2015). Water provided from unregulated flows/spills in 2016 led to a significant bird-breeding event and an abundance of wetland birds.	300 - 1000ML