

Environmental Water Management Plan



Lower Broken Creek and Nine Mile Creek

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SUMMARY

The 2010 lower Broken Creek and Nine Mile Creek Environmental Water Management Plan (WT 2010) has been updated to reflect the changes along the creek over the past 15 years since environmental water was first delivered in 2010.

The planning area includes the Broken and Nine Mile Creeks downstream of Katamatite which has a combined length of 196km. The lower Broken Creek and Nine Mile Creek flow northwest into the Murray River at Barmah Forest, with several adjacent wetlands like Black Swamp (Nine Mile Creek section) near Wunghnu and Kinnairds Wetland at Numurkah. It regularly receives water from the Goulburn and Murray Rivers through irrigation channels (Figure 1).

The creek is an important gathering place and source of food and materials for the Yorta Yorta people with evidence of scarred trees along the creek. The creek also provides social and economic values to the community who live along and benefit from visitors to the site for recreational activities such as fishing, camping and bird watching.

The revision of the 2010 Plan was undertaken by the Goulburn Broken CMA under the guidance of a Project Steering Committee and a Technical Advisory Group consisting of expert scientists relating to geomorphology, water quality and instream productivity, vegetation and fish. The Goulburn Broken CMA facilitated a community workshop to gather local views on the lower Broken Creek and Nine Mile Creek system and priority areas and topics for consideration in the Plan. The Yorta Yorta Nation Aboriginal Corporation were updated throughout the development of the plan and received all correspondence and background work relating to development of the plan. This included an opportunity to review the draft plan and incorporate Yorta Yorta Peoples perspectives and Traditional Ecological Knowledge (TEK) where appropriate.

The lower Broken Creek and Nine Mile Creek have diverse cultural and environmental values including threatened Ecological Vegetation Classes (EVCs) and *Environment Protection Biodiversity Conservation Act 1999* (EPBC Act) (Cth 1999) listed vegetation such as Rigid Water

Milfoil and threatened fish species such as Silver Perch, Trout Cod and Murray Cod. Threats to the environmental values include an altered water regime, pest species, poor water quality and weir pools. Some of the environmental values can be influenced by regulated environmental water deliveries, while others rely on larger natural flows.

Ecological objectives and management objectives were first developed for lower Broken Creek and Nine Mile Creek in 2010 as part of the lower Broken Creek Environmental Water Management Plan (Cth 2012). Building upon the changes from 2010-2024 along the creek and to align with the Basin Plan (Cth 2012) and Victorian Murray Long-term Watering Plan (DELWP 2021) these objectives have been updated (Table 1).

The long-term management goal for lower Broken Creek and Nine Mile Creek is:

“A healthy system that provides water for human and agricultural use, protects and enhances our social, economic and cultural values, and sustains a vibrant range and abundance of native flora and fauna.”

This plan aligns with the Goulburn Broken Catchment Management Authority Waterway Strategy goals, which includes:

- Maintaining or improving the resilience of the region’s waterways.
- Maintain or improve waterways of high community values.
- Maintain or improve populations of threatened aquatic dependent species - including trout cod, Murray cod, Freshwater catfish, golden perch and silver perch.

Consistent with the long-term management goal and the ecological objectives (Table 1), the watering regime for lower Broken Creek and Nine Mile Creek aims to increase water level variability and to identify potential opportunities to vary the predominately consistent flow at some or all the reaches along the creek. Flow targets vary depending

upon the season and reach and will be monitored accordingly.

Table 1: Lower Broken Creek objectives and targets

No	Objective	Target
LBC 1	Maintain or improve distribution and abundance of threatened vegetation species along in-channel and within littoral zones of lower Broken Creek and Nine Mile Creek by 2035.	By 2035, maintain or increase populations of listed aquatic plant species such as Slender Water Ribbons and Rigid Water Milfoil in the lower Broken Creek and Nine Mile Creek at 2022 levels.
LBC 2	Maintain diversity of freshwater ecosystem types such as in-channel, littoral and riparian zones by 2035.	By 2035, aquatic plant species diversity and abundance in lower Broken Creek and Nine Mile Creek is improved or maintained at 2022 levels (excluding post-flood events).
LBC 3	Support the recovery of threatened native fish species in the lower Broken and Nine Mile Creek.	By 2035, the re-introduction of two threatened native fish species within the lower Broken Creek and Nine Mile Creek systems. Measured as re-introduction of two species (e.g. Freshwater Catfish, Southern Pygmy Perch, Flat-headed Galaxias), and species detections in subsequent surveys.
LBC 4	Maintain or enhance self-sustaining native fish populations in the lower Broken Creek and Nine Mile Creek.	By 2035, the trajectory (catch per unit effort, species distribution, population structure) of key target species (Murray Cod, Murray-Darling rainbowfish and Australian Smelt) will be at or above 2024 levels.
LBC 5	Maintain flow conditions to support Rakali, Platypus and turtle populations in the lower Broken Creek and Nine Mile Creek by 2035.	By 2035, show evidence that there has been movement of Platypus, Rakali and turtles into the lower Broken Creek and Nine Mile Creek. Maintain adequate weir pool depth to assist with foraging for food. Ensuring flows during Platypus breeding season have minimum impact on burrows.
LBC 6	Maintain flow conditions to prevent the build-up of Azolla within the lower Broken Creek and Nine Mile Creek and prevent blanketing occurring by 2035.	By 2035, prevent any Azolla blooms occurring.
LBC 7	Maintain lower Broken Creek and Nine Mile Creek flows during periods of drought to provide a refugium to support the long-term survival and resilience of populations of water dependent biota.	Maintain flows at least 250ML/d during drought to provide refugium for water dependent species.

Delivery of environmental water along the lower Broken Creek and Nine Mile Creek can be constrained by:

Irrigation demands: Channel capacity for environmental water deliveries may be limited during peak irrigation season. Demands on input systems to the creek such as the Goulburn and Murray rivers may also impact upon environmental water delivery to the system. High demands may also lead to unwanted elevated flows in the system which may impact lower bank vegetation.

Winter works: Channels used to deliver environmental water along the lower Broken Creek and Nine Mile Creek may be closed over winter for maintenance.

Risks and threats can present in many forms including climate, environmental, community, management, cultural and legal risks. Potentially threatening processes listed in the FFG Act and are relevant to the delivery of environmental water and this plan include:

Altered Flow Regime: Alteration of the natural flow regimes of rivers and streams.

Degraded Riparian Vegetation: Loss and degradation of native vegetation along riverbanks.

Increased Sediment Input: Increase in sediment input into Victorian rivers and streams due to human activities.

Invasive Species: Invasion of native vegetation by environmental weeds and fauna species such as Carp.

Restricted Passage: Barriers preventing the movement of aquatic life due to instream structures.

Loss of in-stream habitat: Removal of wood debris from Victorian streams.

Issues not identified in the FFG Act (DELWP 2022) but is important to note for the lower Broken Creek and Nine Mile Creek are:

Poor Water Quality: Events that impact dissolved oxygen levels and water temperature such as azolla accumulation, heatwaves, and hypoxic, high carbon event.

Loss of physical habitat features: Loss of geomorphic diversity such as deep pools, benches and bars due to river regulation.

Constraint to delivery from weirs: Weirs limit the amount of water that can be pushed through the system and the continuity of the movement of the water.

Risk identification and assessments are undertaken annually at a formal workshop with the Victorian Environmental Water Holder (VEWH) during the development of Seasonal Watering Proposal and include cultural risks related to Yorta Yorta cultural values.

The Plan details key knowledge gaps including the movement of fish in and out of the system, platypus, rakali and turtle abundance and distribution, macroinvertebrate composition and recovery after blackwater events, instream vegetation maintenance, water quality and maintaining dissolved oxygen levels and improved geomorphology.

ACKNOWLEDGEMENTS

The Goulburn Broken CMA respects the Yorta Yorta People and acknowledge the intrinsic connection they have to their country on which lower Broken Creek and Nine Mile Creek are located. We recognise the diversity of their culture and the deep connections they have with Victoria's lands and waters. We value our unique partnership with Yorta Yorta for the health of their people and their traditional country. We respect Yorta Yorta Elders, their ancestors and acknowledge and recognise the Yorta Yorta

People's embedded cultural connections, their bloodlines, their cultural obligations, rights and responsibilities to care for their traditional lands and waters and interact with their country for the purposes of life and resources.

Acknowledgement also goes to the members of the Project Steering Committee and Technical Advisory Group for their generous commitment to the development of this Plan and to the Broken Environmental Water Advisory Group and numerous community members for their input.

ABBREVIATIONS AND ACRONYMS

ACHLMA	Aboriginal Cultural Heritage Land Management Agreement
Basin Plan	Murray-Darling Basin Plan 2012 (Cth)
BCS	Bioregional Conservation Status
BGA	Blue-green Algae
Broken EWAG	Broken Environmental Water Advisory Group
CaLP Act	<i>Catchment and Land Protection Act 1994 (Vic)</i>
CAMBA	China Australia Migratory Bird Agreement
CEWH	Commonwealth Environmental Water Holder
CMA	Catchment Management Authority
DEECA	Department of Energy, Environment and Climate Action
DELWP	Department of Environment, Land and Water Planning
DO	Dissolved Oxygen
EPBC Act	<i>Environment Protection Biodiversity Conservation Act 1999 (Cth)</i>
EVC	Ecological Vegetation Community
EWAG	Environmental Water Advisory Group
EWMP	Environmental Water Management Plan
EWR	Environmental Water Reserve
FFG Act	<i>Flora and Fauna Guarantee Act 1988 (Vic)</i>
GB CMA	Goulburn Broken Catchment Management Authority
GMID	Goulburn-Murray Irrigation District
GMW	Goulburn-Murray Water
Gveg	Goulburn Valley Environment Group
GVW	Goulburn Valley Water
ISC	Index of Stream Condition
IVT	Inter-Valley Trade
JAMBA	Japan Australia Migratory Bird Agreement
MDBA	Murray-Darling Basin Authority
ML	Megalitre (one million litres)
MSC	Moira Shire Council
NTU	Nephelometric Turbidity Units
NVIRP	Northern Victoria Irrigation Renewal Project
PV	Parks Victoria
PEA	Priority Environmental Asset Criteria
PEF	Priority Ecosystem Functions
PoE	Probability of Exceedance
PSC	Project Steering Committee
RAP	Registered Aboriginal Party
ROKAMBA	Republic of Korea – Australia Migratory Bird Agreement
RWS	Regional Waterway Strategy

SWP	Seasonal Watering Proposal
TAG	Technical Advisory Group
TEK	Traditional Ecological Knowledge
VEWH	Victorian Environmental Water Holder
VMLTWP	Victorian Murray Long-term Watering Plan
WMS	Victorian Waterway Management Strategy
VEFMAP	Victorian Environmental Flows Monitoring and Assessment Program
WRFG	Water Plant Functional Groups
YYNAC	Yorta Yorta Nation Aboriginal Corporation

RELEVANT PLANS AND LEGISLATION

The plans and legislation listed below are relevant and have been referenced in this document.

International treaties, conventions and initiatives	<p>Japan Australia Migratory Agreement (JAMBA) 1974 (Cth 1981)</p> <p>Convention on the Conservation of Migratory Species of Wild Animals (Bonn Convention) 1979 (CMS 1979)</p> <p>China Australia Migratory Agreement (CAMBA) 1986 (Cth 1986)</p> <p>Republic of Korea Australia Migratory Agreement (ROKAMBA) 2007 (Cth 2007)</p>
Commonwealth legislation and policy	<p><i>Environmental Protection Biodiversity Act 1999</i> (EPBC Act) (Cth 1999)</p> <p><i>Water Act 2007</i> subparagraph 44(3)(b)(i) Basin Plan 2012 (Cth 2012)</p>
Victorian legislation	<p><i>Flora and Fauna Guarantee Act 1988</i> (FFG Act) (DELWP 2022)</p> <p><i>Water Act 1989</i> (Vic) (Vic 1989)</p> <p><i>Catchment and Land Protection Act 1994</i> (CaLP Act) (Vic 1994)</p> <p><i>Aboriginal Heritage Act 2006</i> (Vic 2006)</p>
Plans	<p>Lower Broken Creek and Nine Mile Creek Environmental Water Management Plan (GBCMA 2010)</p> <p>Environmental Water Delivery: Lower Broken Creek (Cottingham and SKM 2011)</p> <p>Victorian Waterway Management Strategy (DEPI 2013)</p> <p>Goulburn Broken Catchment Management Authority Waterway Strategy (GBCMA 2014)</p> <p>Lower Broken Creek FLOWS Study. Issues and flows recommendations paper (Jacobs 2019)</p> <p>Victorian Murray Long-term Watering Plan (DELWP 2021)</p> <p>Goulburn Broken Regional Catchment Strategy 2021-2027 (GBCMA 2021)</p> <p>Yorta Yorta Whole of Country Plan 2021-2030 (YYNAC 2021)</p>

1 INTRODUCTION

Environmental water management in Victoria is firmly established with water recovery enabling significant volumes of water being returned to the environment. The increased environmental water availability has provided opportunities to protect, restore and reinstate high value ecosystems throughout Victoria.

Environmental watering in Victoria has historically been supported by management plans such as this one, that document key information including the watering requirements of an asset, predicted ecological responses and water delivery arrangements. These plans support annual decisions about which sites should receive water and assist managers to evaluate how well those assets respond to the water they receive or what could be done better.

Environmental water in Victoria is managed as an integral part of the Victorian Waterway Management Program, with the state-level Victorian Waterway Management Strategy 2013 (DEPI 2013) providing the overarching framework for environmental water management. Regional Waterway Strategies (RWSs) drive the implementation of the Victorian Waterway Management Strategy at the regional level. Information from the region's Regional Waterway Strategy is a key input to environmental water planning arrangements, including the selection of eligible assets to receive environmental water. Environmental water management plans (EWMPs) are site-specific plans developed for those assets deemed a priority to receive environmental water through the Regional Waterway Strategy development process (Figure 2).

In the Murray-Darling Basin, environmental water management is further underpinned by the Basin Plan 2012 (Cth 2012) and the associated Basin-wide environmental watering strategy (MDBA 2019). In accordance with Basin Plan requirements, Victoria has also developed relevant water resource plans and long-term watering plans (DELWP 2021).

Victoria's Catchment Management Authorities (CMAs), Melbourne Water, Department of Energy, Environment and Climate Action, the Victorian Environmental Water Holder and Traditional Owner groups have worked together to develop Environmental Water Management Plans for most watered assets throughout Victoria. These plans are continually updated through an adaptive management process.

A primary purpose of the plans is to provide a consistent set of documents that support Seasonal Watering Proposals (SWPs) to be submitted by asset managers to the Victorian Environmental Water Holder annually. The supporting information includes:

- Lead management agencies and their management responsibilities.
- The water-dependent environmental, social, and economic values of the asset.
- The asset's environmental condition and threats.
- Environmental objectives and intended watering regime.
- Contributions from Traditional Owner groups (included in an Environmental Water Management Plan with free, prior, and informed consent) that may include information about cultural values, management goals, environmental and cultural objectives and intended watering regime.
- Opportunities for improved water delivery, efficiency or capacity through structural works or other measures.
- Scientific knowledge gaps and recommendations for future work.

This Plan establishes priorities for the use of environmental water along the lower Broken Creek and Nine Mile Creek within the Broken catchment described in Section 3.1 Catchment setting. This revision builds on iterations of the 2010 Plan and has been revised to reflect upon learnings over the past 14 years of water delivery to the site and improve alignment of lower Broken Creek and Nine Mile Creek objectives to the Basin Plan's Environmental Watering Plan Framework (MDBA 2019) and Victoria's Long Term Watering Plans (DELWP 2021).

The 2010 Plan has been used to guide environmental water delivery to the site for the past 15 years. Monitoring of environmental water delivery to lower Broken Creek and Nine Mile Creek has improved Goulburn Broken Catchment Management Authority's (Goulburn Broken CMA) understanding of ecological and hydrological needs and responses and operational conditions that are to be considered at the time of delivery. A FLOWS study by Jacobs (2019) has also been used to inform environmental watering decisions and the updated Plan.

In Victoria, the lower Broken Creek and Nine Mile Creek has been designated as a priority waterway for receiving environmental water. Environmental water deliveries began in 2010 and have continued annually. The lower Broken Creek system encompasses four reaches, including the section of Boosey Creek from Katamatite to its junction with the Broken Creek, the main Broken Creek from the Boosey Creek junction to Barmah, and the Nine Mile Creek anabranch (Figure 1). Despite being heavily regulated and modified, lower Broken Creek and Nine Mile Creek hosts a variety of water-dependent values within what is now considered a unique and 'novel ecosystem'. Environmental water deliveries occur independently or in conjunction with other water allocations to preserve and enhance these important ecological features.

Development of the Environmental Water Management Plan has been led by the Goulburn Broken Catchment Management Authority in collaboration with a Project Steering Committee composed of representatives from the Department of Energy, Environment and Climate Action, the Victorian Environmental Water Holder, the Commonwealth Environmental Water Holder, Goulburn-Murray Water, Goulburn Valley Water and Parks Victoria. Yorta Yorta Nation Aboriginal Corporation were invited to the Project Steering Committee but were not active participants. A Technical Advisory Group was also engaged to provide scientific input including experts in geomorphology, botany, fish ecology, water quality and instream productivity.

Development of the Plan involved:

- A review of existing technical background information and provision of recommended updates by the Technical Advisory Group based on the latest science.
- A workshop with the local community in Nathalia and an email out of key consultation questions to local contacts to gain community input to the Plan.
- A direction-setting workshop with the Project Steering Committee and Technical Advisory Group to guide drafting of the Plan.
- Review of the draft Plan by the Project Steering Committee and Technical Advisory Group, with feedback incorporated into the final Plan.

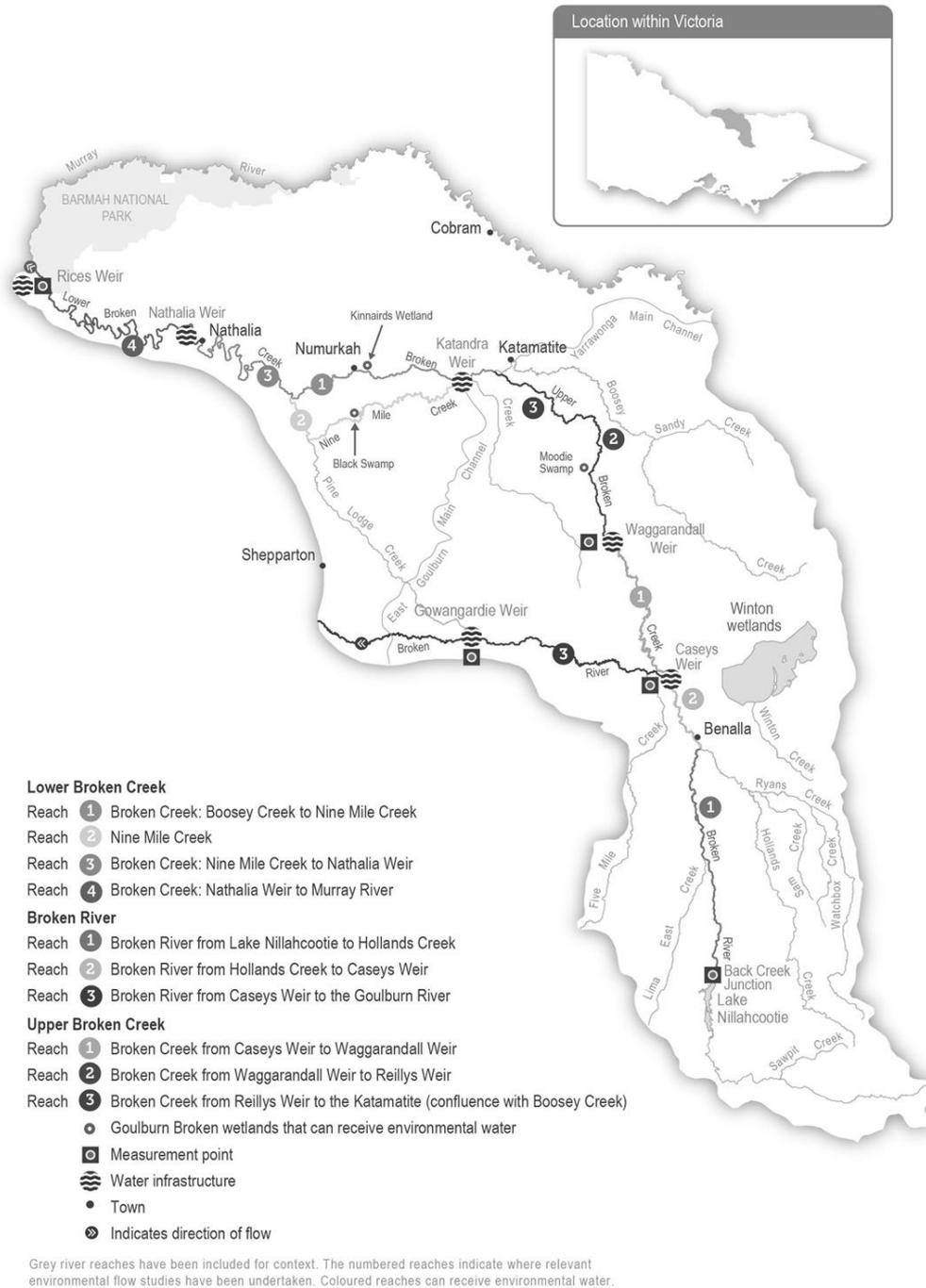


Figure 1: Location of lower Broken Creek and Nine Mile Creek

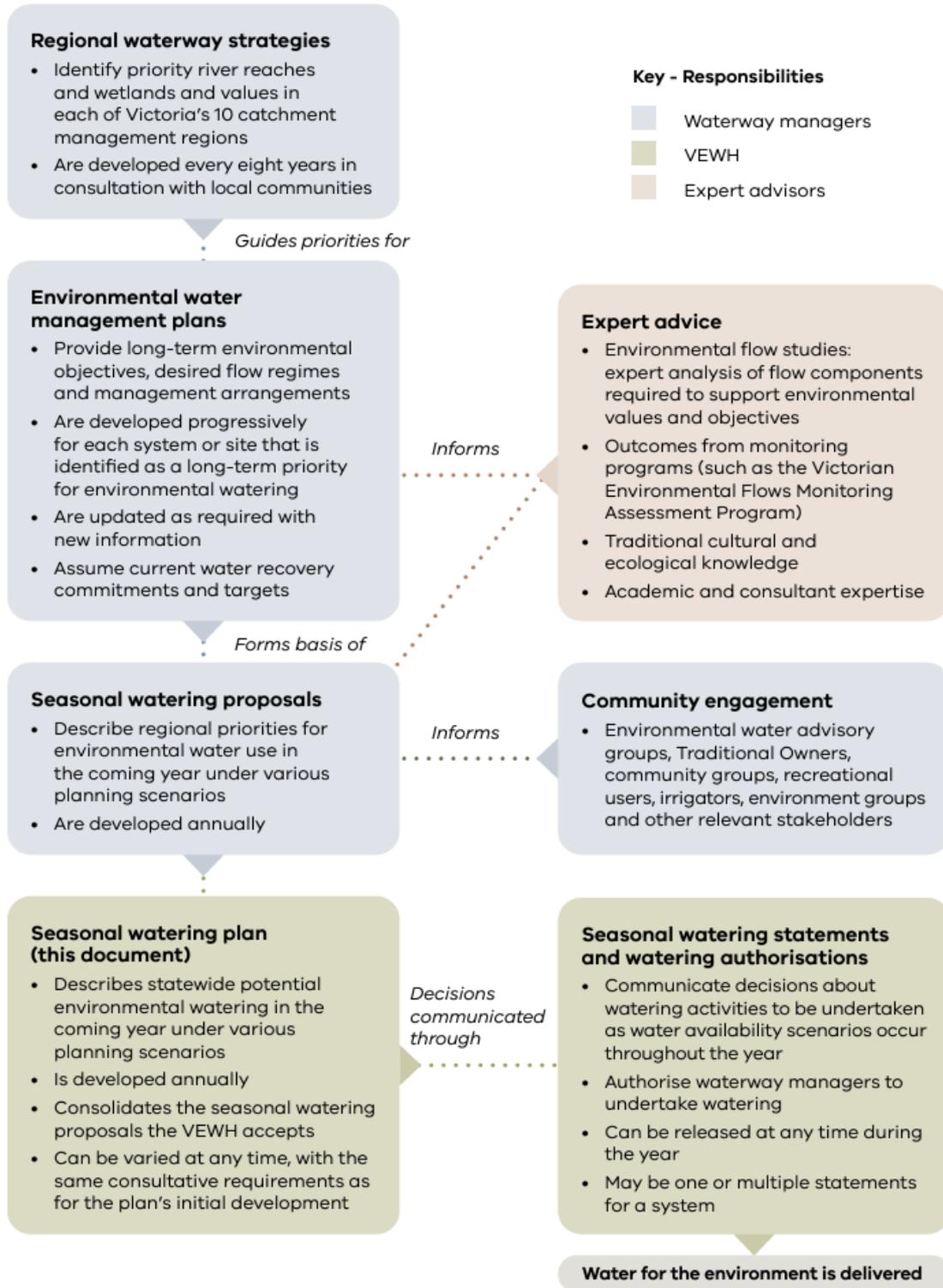


Figure 2: Victoria's environmental watering program planning framework (VEWH 2024).

1 PARTNERSHIP AND CONSULTATION

1.1 CONSULTATION

The revision of the 2010 Plan was undertaken by the Goulburn Broken CMA under the guidance of a Project Steering Committee (PSC) comprised of representatives from:

- Department of Energy, Environment and Climate Action (DEECA),
- Victorian Environmental Water Holder (VEWH),
- Commonwealth Environmental Water Holder (CEWH),
- Parks Victoria (PV),
- Goulburn-Murray Water (GMW),
- Goulburn Valley Water (GVW), and
- Yorta Yorta Nation Aboriginal Corporation (YYNAC).

The Yorta Yorta Nation Aboriginal Corporation were invited to partner in development of the Environmental Water Management Plan and to be a member of the PSC but were unable to actively participate in the process. As an alternative, a representative from Yorta Yorta Nation Aboriginal Corporation remained on the PSC email list and received all correspondence and background work relating to development of the plan, with the opportunity to participate remaining available throughout the process. This included an opportunity to review the draft plan and incorporate Yorta Yorta Peoples perspectives and Traditional Ecological Knowledge (TEK) where appropriate.

The Project Steering Committee met at key points during the Plan development process to provide input, guidance and feedback.

The Goulburn Broken CMA engaged a Technical Advisory Group (TAG) consisting of expert scientists relating to geomorphology, water quality and instream productivity, vegetation and fish, to review existing documented information on lower Broken Creek and Nine Mile Creek and update this where necessary using the best available knowledge regarding:

- water-dependent environmental values and the current condition of values,
- water-related threats to values,
- environmental goals, objectives and targets,
- the required water regime to achieve the objectives, and
- priority complementary works to support achievement of the objectives.

The TAG also assisted with the alignment of the Plan to the Basin Plan.

Both the PSC and TAG participated in inception meetings, a direction-setting workshop held in May 2023 to inform the Plan and reviewed the draft Plan.

The Goulburn Broken CMA facilitated a community workshop in Nathalia in May 2023 to gather local views on the lower Broken Creek and Nine Mile Creek system and priority areas and topics for consideration in the Environmental Water Management Plan. Four focus questions discussed included:

1. What do you value most about the creek?
2. What would you like to see improved?
3. What do you think are the highest priorities to focus on?
4. What does a perfect lower Broken Creek and Nine Mile Creek environment look like?

Following the workshop, these questions were circulated to additional local community members and relevant contacts through the Goulburn Broken CMA's existing email contact network and the Broken Environmental Water Advisory Group (Broken EWAG). A summary of the community consultation findings is provided in **Appendix A**.

Table 2 summarises the level of engagement using the IAP2 Public Participation Spectrum (IAP2 2018) for those involved (or invited to be involved) in the Plans development.

Table 2: Engagement undertaken in development of the lower Broken Creek and Nine Mile Creek Plan

Category	Who	IAP2 level of engagement	Engagement methods	Engagement Purpose
Government Agencies	Department of Energy, Environment and Climate Action Victorian Environmental Water Holder Commonwealth Environmental Water Holder Goulburn-Murray Water Goulburn Valley Water Parks Victoria	Collaborate	Active member of the PSC	Partner with the Goulburn Broken CMA to guide the development of the Plan.
Traditional Owners	Yorta Yorta Nation Aboriginal Corporation	Collaborate	Inactive member of the PSC	Invitation to partner with the Goulburn Broken CMA to guide the development of the Plan.
Local community	Landholders and irrigators Town residents	Consult	Community workshop Email Broken EWAG	Ensure understanding of the Plan and intended outcomes. Seek input into the plan's development. Provide feedback on draft Plan.
Recreational Users	Goulburn Valley Association of Angling Clubs Numurkah Fishing Club	Consult	Community workshop Email feedback	Ensure understanding of the Plan and intended outcomes. Seek input into the plan's development. Provide feedback on draft Plan.
Community Groups	Goulburn Valley Environment Group Goulburn Murray Landcare Network Broken Boosey Conservation Management Network Broken Creek Field Naturalists Club	Consult	Community workshop Email Broken EWAG	Ensure understanding of the Plan and intended outcomes. Seek input into the plan's development. Provide feedback on draft Plan.
Technical experts	Scientists from the Arthur Rylah Institute for Environmental Research, Streamology, and Rivers and Wetlands	Collaborate	Member of the Technical Advisory Group	Guide the technical content of the Plan.

1.2 THE YORTA YORTA PEOPLE

Yorta Yorta are the Traditional Owners of the country upon which the lower Broken Creek and Nine Mile Creek system occurs. Yorta Yorta land and water lies on both sides of the Murray River from Cohuna in Victoria to Howlong in New South Wales. It includes towns such as Echuca, Shepparton, Benalla, Corowa, and Wangaratta and extends northwards to just south of Deniliquin (Figure 3).



Figure 3: Yorta Yorta Country

Lower Broken Creek and Nine Mile Creek supports a diverse range of culturally significant plants and animals. Common reed contained within the slack water provides important material for tools whilst also providing refuge for culturally important fish species. The creek has significant stands of old growth river red gum containing important habitat and exhibiting scars made from carving out canoes and coolamons (Whittaker 2021).

The Yorta Yorta Nation Aboriginal Corporation (YYNAC) is the representative body that provides the interface between government and the Yorta Yorta People and is a Victorian Registered Aboriginal Party (RAP) under the *Aboriginal Heritage Act 2006 (Vic 2006)* with decision making responsibilities for protecting Aboriginal cultural heritage, and other matters within the Registered Aboriginal Party area. Yorta Yorta Nation Aboriginal Corporation and Goulburn Broken CMA have established an Aboriginal Cultural Heritage Land Management Agreement (ACHLMA). This agreement provides a framework for protecting and managing Aboriginal cultural heritage during ongoing, routine land management activities within a Registered Aboriginal Party area including works to assist with environmental water releases along lower Broken Creek and Nine Mile Creek.

The Yorta Yorta Nation Aboriginal Corporation have identified several objectives (Table 3), outcomes and actions related to water management on Yorta Yorta Country. The following were identified through their contribution to Victoria's water resource plans (DELWP 2019).

Table 3: Yorta Yorta objectives and outcomes for water management

Objective	Outcome
To look after country through land and water management to restore and maintain our wetlands, rivers, waterways, tributaries, and lagoons which in turn look after our flora and fauna that make up cultural lore.	Increase awareness, understanding, respect and protection of Yorta Yorta interests and custodianship. Healthy country and economic outcomes for Yorta Yorta people.
To have decision making in the water planning process, water sharing and distribution.	Equal influence ‘at the table’ with other representatives from the water industry. Increased integration across the industry.
To develop a cultural flow that will complement the current water management process and have input to the current water flow that goes through country.	Watering country for healthy country and achieving economic outcomes for Yorta Yorta people.
To build Traditional Ecological Knowledge (TEK) into strategies where appropriate e.g. river red gum thinning, protection of wetlands, links with cultural lore, bring back native animals and plants and involve Elders onsite to discuss TEK.	“Bring people back, bring Country back.” It will provide a better living culture, better caring for Country and better outcomes for Country.

*TEK (Traditional Ecological Knowledge) is the knowledge base that has been handed down to the Yorta Yorta People and has direct contact with their cultural environment.

The Yorta Yorta Whole-of-Country Plan 2021-2030 (Table 4) states the following actions that are relevant to environmental water management generally and within lower Broken Creek (YYNAC 2021).

Table 4: Yorta Yorta Whole-of-Country Plan for water management that may be relevant to this plan

Walla – Water (pg26 and 27)	
<i>Pursue our inherent right to water entitlements that are legally and beneficially owned by Yorta Yorta of a sufficient quantity and quality to improve our spiritual, cultural, environmental, social and economic needs.</i>	
Actions	
WW12	Seek water policies and operational flows that: <ul style="list-style-type: none"> a. achieve healthier Country and better outcomes for ecosystems, and native plants and animals; and b. recognise and deliver legal water entitlements that meet broader Yorta Yorta cultural, social and economic needs.
WW13	Ensure water rights are negotiated in expanded management rights in co-management, joint management, treaty and other processes.
WW15	Provide information and training to river operators and other agencies about culturally important plants and animals and their water and habitat needs to improve the cultural and environmental outcomes from watering operations.
WW18	Support government policies to allow waterways and floodplain wetlands to flood naturally, and the removal or managed weathering away of levees and constructed barriers.

Goulburn Broken CMA along with other relevant agencies will continue to look for opportunities to work closely with Yorta Yorta Nation Aboriginal Corporation in the management of lower Broken Creek and Nine Mile Creek.

2 ASSET OVERVIEW

2.1 CATCHMENT SETTING

The lower Broken Creek and Nine Mile Creek is within the Broken Basin of northern Victoria. The Basin covers 772,386 hectares or 3.4 percent of Victoria and is bordered to the south and west by the Goulburn Basin, to the east by the Ovens Basin and to the north by the Murray River (Figure 4). The Broken Basin includes the Murray Fans Bioregion to the north and the Victorian Riverina Bioregion (Section 3.1.4) to the south.

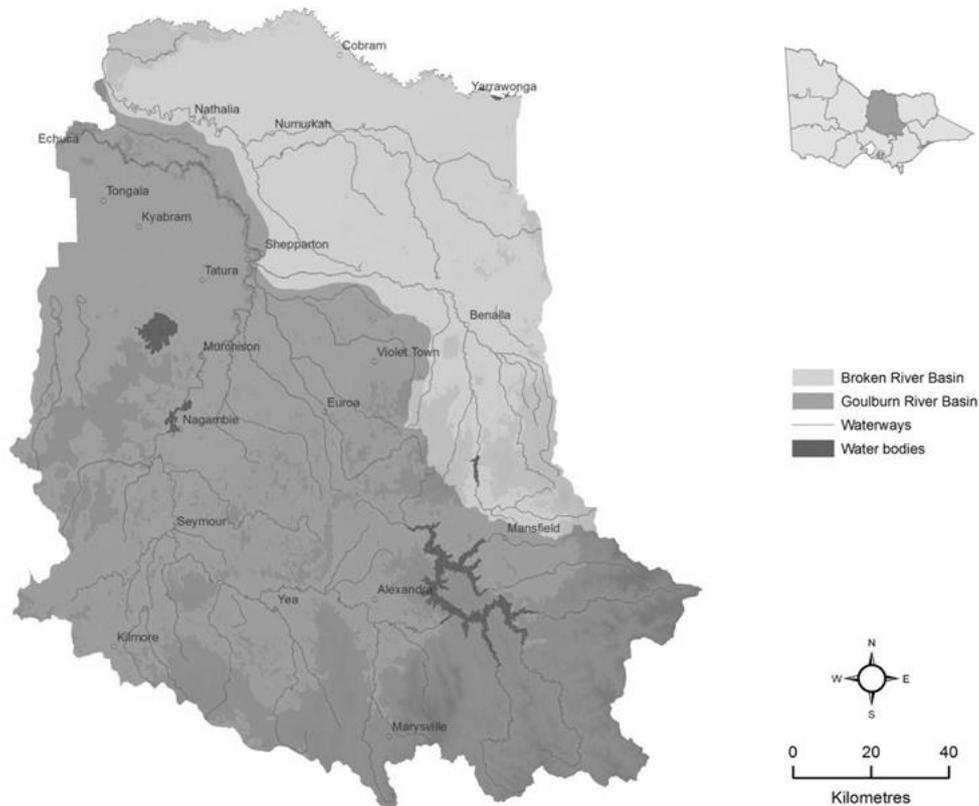


Figure 4: The Broken River Basin within the broader Goulburn Broken catchment

The Broken Basin consists of two connected waterways: the Broken River in the south and the Broken Creek in the north. The Broken Creek diverges from the Broken River near Benalla at Casey's Weir and flows northwest into the Murray River at Barmah Forest. The upper 89 km of Broken Creek receives water from the Broken River via Casey's Weir, while the lower 196 km, including Nine Mile Creek, gets water primarily from the Goulburn and Murray Rivers through irrigation channels. Consequently, the upper and lower sections function differently hydrologically and are managed separately for environmental water delivery, though they are connected during high flows.

The lower Broken Creek catchment spans 3,300 km² in the northern Broken Basin, including the western slopes of the Warby Ranges and northern slopes of the Dookie foothills. It has a low gradient, supporting a few lowland streams. The lower Broken Creek system encompasses the regulated section of Boosey Creek from Katamatite to lower Broken Creek and four reaches of the lower Broken Creek, including Nine Mile Creek. This catchment also includes the unregulated western section of Boosey Creek and other minor tributaries. The creek flows northwest into the Murray River at Barmah Forest.

Nine Mile Creek is an ancient course of the Broken River, formed around one hundred million years ago. It became an anabranch of the Broken Creek and is now a highly regulated system with adjacent wetlands like Black Swamp and Purdie's Swamp near Wunghnu. Geomorphically, two zones exist in the lower Broken Creek: downstream of Waaia township, the creek follows the ancestral Tallygaroopna Channel with a larger meander, while upstream, the creek is more sinuous with smaller meanders indicative of a recent channel (Tickell 1989).



Figure 5: Nine Mile Creek

The catchment has been cleared for agriculture, forming part of the Goulburn Murray Irrigation District (GMID). The Murray Valley Irrigation Area is north of the creek, and the Shepparton Irrigation Area is to the south, supporting dairying, grazing, cropping, and horticulture. Despite extensive clearing, remnant vegetation and wetlands along the creek provide crucial habitats for native flora and fauna, much of which is protected in reserves.

The lower Broken Creek and Nine Mile Creek are part of the Goulburn Murray Irrigation District's water distribution network and have been regulated for over 100 years, significantly altering the natural flow regime. The creek now conveys regulated water to meet local and downstream irrigation demands, creating a novel ecosystem within the Broken Basin and the southern Murray-Darling Basin.

2.2 LAND STATUS AND MANAGEMENT

Most of the lower Broken Creek and Nine Mile Creek is within a narrow band of public land managed by either Parks Victoria or Department of Energy, Environment and Climate Action. In terms of Parks Victoria managed land, this includes the Broken-Boosey State Park (44km), Numurkah Natural Features Reserve (50km), Nathalia Natural Features Reserve (27km) and Barmah National Park (5km). The remaining lower Broken Creek water frontage includes a mix of private land management through Department of Energy, Environment and Climate Action's Water Frontage Licenses, General Licenses and Riparian Management Licenses as well as unlicensed areas managed by the Department. There are a small number of landholders along the creek with pre-emptive¹ rights. A range of government agencies are responsible for ensuring that management of the creek and environmental water delivery complies with a broad range of legislative requirements.

Lead organisations and their key management roles and responsibilities are summarised in Table 5.

The successful management of the system therefore relies on effective cooperation and coordination between these groups and the broader community.

Table 5: Lead organisations and their key roles and responsibilities in management of the lower Broken Creek and Nine Mile Creek

Agency	Roles and responsibilities
Yorta Yorta Nation Aboriginal Corporation (YYNAC)	Is the Registered Aboriginal Party (RAP) under the <i>Aboriginal Heritage Act 2006 (Vic)</i> for the creek and the representative body that provides the interface between government and Yorta Yorta Traditional Owners. Yorta Yorta Nation Aboriginal Corporation have decision making responsibilities that are recognised by the State of Victoria for protecting their Aboriginal cultural heritage, and other matters within the RAP area. Yorta Yorta Nation Aboriginal Corporation collaborate with the Goulburn Broken CMA regarding environmental water delivery within Yorta Yorta Country, including to the lower Broken Creek and Nine Mile Creek.
Department of Energy, Environment and Climate Action (DEECA)	Provide financial, policy and strategic support for the management of public and private land. Management of flora and fauna, State Forest and public land water frontage. Management of hunting and domestic stock licensing on public land.
Goulburn Broken Catchment Management Authority (GB CMA)	Implementation of the Goulburn Broken Regional Catchment Strategy 2021-27 (GBCMA 2021). Works on waterways, regional drainage and floodplain management, and coordinating Commonwealth and State natural resource management investment. Determining the environmental water requirements of wetlands and waterways, developing, and submitting seasonal watering proposals to the Victorian Environmental Water Holder for consideration, and managing the delivery of environmental water in accordance with the Victorian Environmental Water Holders Seasonal Watering Plan.
Goulburn-Murray Water (GMW)	The key water delivery agency. Manages water related services including storage, delivery and drainage systems across northern Victoria including water and assets in the lower Broken and Nile Mile Creeks.
Murray-Darling Basin Authority (river operations)	Requests GMW to deliver Inter-Valley Trade and Murray bypass flows through lower Broken Creek and Nine Mile Creek (referred to as water-in-transit deliveries) when required to meet downstream demands.
Moira Shire Council (MSC)	Regulate local development through the planning scheme, on-ground works, and management of local roads and urban drainage.

¹ Pre-emptive rights typically secured access to reliable water in creeks or rivers, but the law forbade control of dual water frontages to prevent undue monopoly of water supplies.

Parks Victoria (PV)	Management of State Parks, National Parks and Natural Features Reserves on behalf of Department of Energy, Environment and Climate Action.
Victorian Environmental Water Holder (VEWH)	Management of Victorian environmental water entitlements on behalf of the Minister for Environment. Development of Seasonal Watering Plans derived from CMA's Seasonal Watering Proposals. Coordination of environmental water provision across Victoria (in consultation with the Commonwealth Environmental Water Holder). Provides approval for the provision and delivery of environmental water to lower Broken Creek and Nine Mile Creek.
Commonwealth Environmental Water Holder (CEWH)	Management of Commonwealth environmental water entitlements. Provision of environmental water for use in lower Broken Creek and Nine Mile Creek.

2.3 ASSET CHARACTERISTICS

Key characteristics of the lower Broken Creek and Nine Mile Creek are provided in Table 6 below.

Table 6: Key characteristics of lower Broken Creek and Nine Mile Creek

Characteristic	Description
Name	Lower Broken Creek (including Nine Mile Creek)
Traditional Owners	The Yorta Yorta People
Land managers	Parks Victoria and Department of Energy, Environment and Climate Action
Length	196km
Bioregion	Murray Fans, Victorian Riverina
Ecosystem type	Permanent lowland stream as classified in Australian National Aquatic Ecosystem database (AET 2012)
Conservation significance	Floodplain of lower Broken Creek and Nine Mile Creek is listed in <i>A Directory of Important Wetlands in Australia (VIC 036)</i> (EA 2001)
Surrounding land use	Riparian conservation reserves, irrigated agriculture, dryland agriculture
Towns	Katamatite, Numurkah, Wunghnu, Nathalia, Barmah
Regulated water supply	Murray River at Lake Mulwala via Yarrawonga Main Channel Goulburn River at Goulburn Weir via East Goulburn Main
Unregulated water supply	Upper Broken Creek Boosey Creek
Reach 1 specific features*	Reach 1a - Boosey Creek downstream of the Murray Valley 7/3 Channel outfall to the Broken Creek confluence: <ul style="list-style-type: none"> Length - 4.1km Regulating structures – Murray Valley 7/3 channel outfall. Reach 1b - Broken Creek downstream of the Boosey Creek confluence to the Nine Mile Creek confluence: <ul style="list-style-type: none"> Length – 38.5km Regulating structures – East Goulburn Main channel outfall, Katandra Weir, Murray Valley No. 4 Main outfall, Murray Valley 6/6 outfall, Melville St Weir (Numurkah), Station St Weir (Numurkah). Total reach 1 length – 42.6km
Reach 2 specific features*	Nine Mile Creek from Katandra Weir to the Broken Creek confluence: <ul style="list-style-type: none"> Length - 49.8km Regulating structures – Katandra Weir.
Reach 3 specific features*	Broken Creek from the Nine Mile Creek confluence to the Nathalia Weir: <ul style="list-style-type: none"> Length - 37.9km Regulating structures – Murray Valley 15/6 outfall, Hick's outfall, Murray Valley Jewells outfall, Nathalia Weir.
Reach 4 specific features*	Broken Creek downstream of the Nathalia Weir to the Murray River: <ul style="list-style-type: none"> Length - 65.8km Regulating structures – Chinamens Weir, Murray Valley Flanner's outfall, Ball's Weir, Lucke's Weir, Harding's Weir, Hollands outfall, Schiers Weir, Kennedy's Weir, Rice's Weir.

* Note: regulating structures are listed in order from upstream to downstream. Outfalls not listed as Murray Valley outfalls are located in the Shepparton Irrigation Area.

2.4 ENVIRONMENTAL WATER SOURCES

The Environmental Water Reserve (EWR) is a legally designated portion of water allocated to support environmental needs. This reserve includes minimum river flows, unregulated flows, and specific environmental entitlements stored in reservoirs. These entitlements can be released when necessary to wetlands or waterways to protect or enhance their ecological health. The Minister for Environment holds these environmental entitlements, with management delegated to the Victorian Environmental Water Holder.

In the lower Broken Creek and Nine Mile Creek system, environmental flow needs are primarily fulfilled by three sources: environmental water, Murray bypass flows², and the Goulburn to Murray Inter-Valley Trade³ (IVT). Since the lower Broken Creek and Nine Mile Creek system lacks its own environmental entitlements or water storage facilities, environmental water must be delivered from the Murray or Goulburn Rivers through the irrigation channel network (Figure 5).

All water available for use in the lower Broken and Nine Mile Creeks are referred to in Table 7.



Figure 6: Environmental water delivery through a Murray Valley outfall into lower Broken Creek

² Murray bypass flows: MDBA deliveries via the Murray Valley Irrigation district into the lower Broken Creek system that would have otherwise gone down the Murray River system.

³ Inter-valley Trade: water that is “owed” from one river valley to another as a result of water trade.

Table 7: Sources of water for lower Broken Creek and Nine Mile Creek (Vic 2024)

Water Source	Responsible agency	Description	Conditions
Bulk Entitlement (Eildon – Goulburn Weir) Conversion Order 1995			
Goulburn Water Quality Allowance	GMW	30 GL per year	Maintenance of water quality.
Environmental water entitlements			
Bulk Entitlement (River Murray - Flora and Fauna) Conservation Order 1999	VEWH	95,571 ML high reliability water shares and 30,860 ML low reliability water shares.	Availability determined by agreement with the VEWH.
NVIRP entitlement	VEWH	One-third of water savings created in the Goulburn System from modernisation works completed as part of Stage 1 of the Northern Victorian Irrigation Renewal Project. Issued to the VEWH as 17,703 ML high reliability water shares.	Availability determined by agreement with the VEWH.
Environmental Entitlement – Living Murray	MDBA	39,625 ML Goulburn high reliability water shares and 156,980 ML low reliability water shares. 9,589 ML Murray high reliability water shares and 101,850 ML low reliability water shares.	Water allocated to this entitlement must be used for the Living Murray ‘Icon sites.’ However, this water can provide environmental benefits in the lower Broken Creek and Nine Mile Creek system en-route to the Murray River.
Commonwealth Environmental Water Holdings	CEWH	The watering schedule between CEWH and VEWH allows up to 50,000 ML to be available for the lower Broken Creek and Nine Mile Creek, subject to environmental need and water availability. Additional environmental allocations may be available from the CEWH holdings if required.	Approved by the CEWH and sourced from Murray and/or Goulburn holdings. Water use is subject to agreement with the representatives from the CEWH.
Water-in-Transit			
Goulburn River Inter-Valley Trade	MDBA/GMW	Varies (up to 350,000 ML) depending on trade amounts.	Must be called by MDBA. Limited to spare channel capacity.
Murray River bypass flows	MDBA	Varies depending on downstream demand.	Must be called by MDBA. Limited to spare channel capacity.
Other			
Murray River flows	MDBA /VEWH	Unregulated flows	Available when Murray River flow is unregulated.
Boosey Creek and upper Broken Creek flows	VEWH	Unregulated flows	Available when Boosey Creek and upper Broken Creek flow is unregulated.
Goulburn Valley and Murray Valley irrigation supplies	GMW	Irrigation water	Supply dictated by demand and channel capacity.

2.5 HYDROLOGICAL REGIME AND SYSTEM OPERATIONS

Hydrology is a major driver of the physical, chemical and biological structures and processes in flowing waters and their floodplains. Management of the hydrology of the lower Broken and Nine Mile Creek is important to maintain and promote their health.

2.5.1 Pre-regulation

The lower Broken Creek and Nine Mile Creek have a long, diverse history. Yorta Yorta people have cared for the creek for thousands of years before settlement occurred. Food and medicine and fibres would have been used along the creek to support Yorta Yorta People.

The lower Broken Creek and Nile Mile Creek were naturally ephemeral systems with flow occurring predominantly during winter and spring in response to large rainfall events in the upper Broken Creek and Boosey Creek catchments. The Broken Creek would have also received flows from the Broken River in approximately one year in every five (Reich, McMaster et al. 2010).

The creeks would regularly stop flowing in summer and autumn, resulting in the creek contracting to a series of isolated pools.

2.5.2 Post-regulation

With the introduction of regulation over one hundred years ago, the ephemeral creek changed to a perennial system with summer and autumn dominant flows and permanent weir pools. Lower Broken Creek and Nine Mile Creek is now considered a backbone channel of the Goulburn Murray Irrigation District network and is used to supply local pumping diverters as well as convey water from the Murray and Goulburn Rivers to meet downstream demands. It also serves a key drainage function for the Murray Valley and Shepparton Irrigation Areas, with several drainage outfalls entering the creek along its length. There are nine weirs along the lower Broken Creek and Nine Mile Creek, each with fishways (Figure xx Section xx). The operating level of each weir pool is carefully managed and stable to ensure adequate water access for pumping. Outside of weir pool areas, the creek remains a flowing system, albeit with a typically reversed flow regime.

The hydrological regime is permanent water during the irrigation season (from 15 August to 15 May). Over this period, flow enters the creek from the Murray River (via the 7/3 channel near Katamatite) and Goulburn River (via the East Goulburn Main channel just downstream of Katamatite). A maximum flow rate of 310 ML/d can enter the creek from these two upstream channels, with additional water able to enter the creek from other minor outfalls along its length. As a result, maximum regulated flows at Rices Weir⁴ are around 450 ML/d. The flow at Rices Weir is however a function of upstream inflows and pumping extractions. If local pumping demand is high, then the flow at the downstream end of the creek reduces. As a result, flow at Rices Weir during the irrigation season can be quite variable but is typically between 200-400 ML/d (Figure 7).

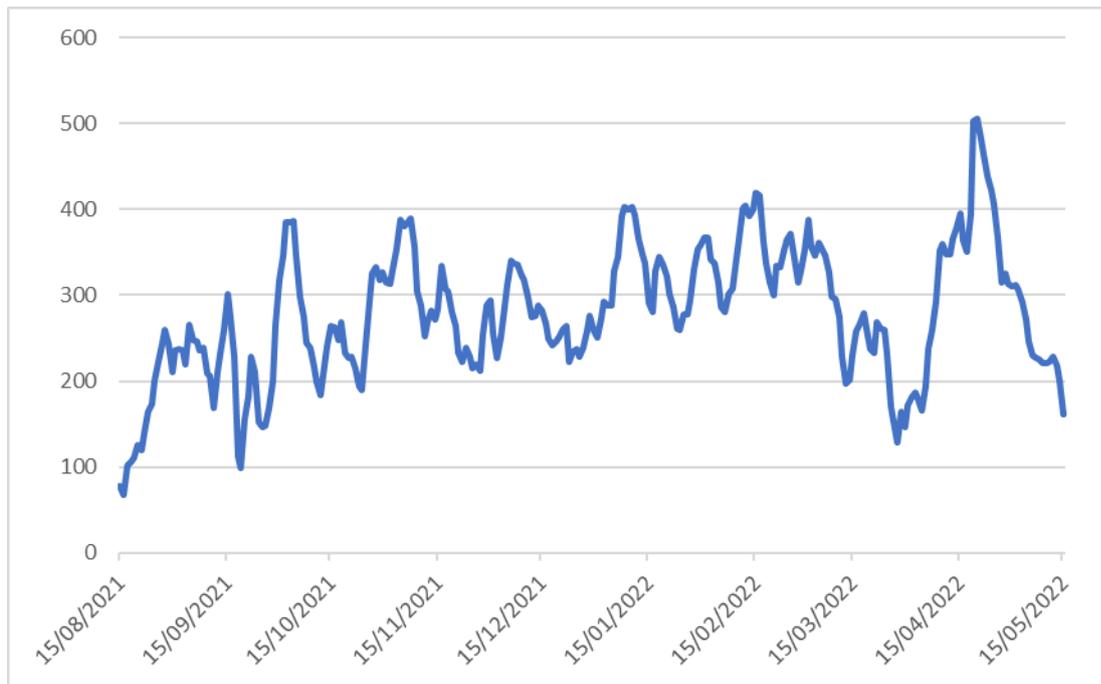


Figure 7: An example of variable flows (ML/d) at Rices Weir between 15 August 2021, and May 15 2022 (Irrigation season).

Flow can be higher though if local irrigation demand is low and downstream demands are high, allowing for larger volumes of water-in-transit deliveries (Inter-Valley Trade and Murray bypass flows) to be delivered to the Murray River via lower Broken and Nine Mile Creek. This can result in flow consistently above 400 ML/d (Figure 9).

Environmental water was first delivered to lower Broken Creek and Nine Mile Creek in 2010, with deliveries occurring every year since (Figure 8). In some years it has provided the bulk of the flow in the creek, while in other years very little environmental water has been required due to other water deliveries (Figure 10). Environmental water aims to provide adequate flows along the full length of the creek (through to Rices Weir) to the Murray River, by setting a specified flow target at Rices Weir. This reduces the chance of local diversions taking the bulk of water out of the creek and reducing the habitat and water quality, particularly at the downstream end.

⁴ The most downstream gauge within the lower Broken Creek and Nine Mile Creek system used to measure environmental water flow rates.

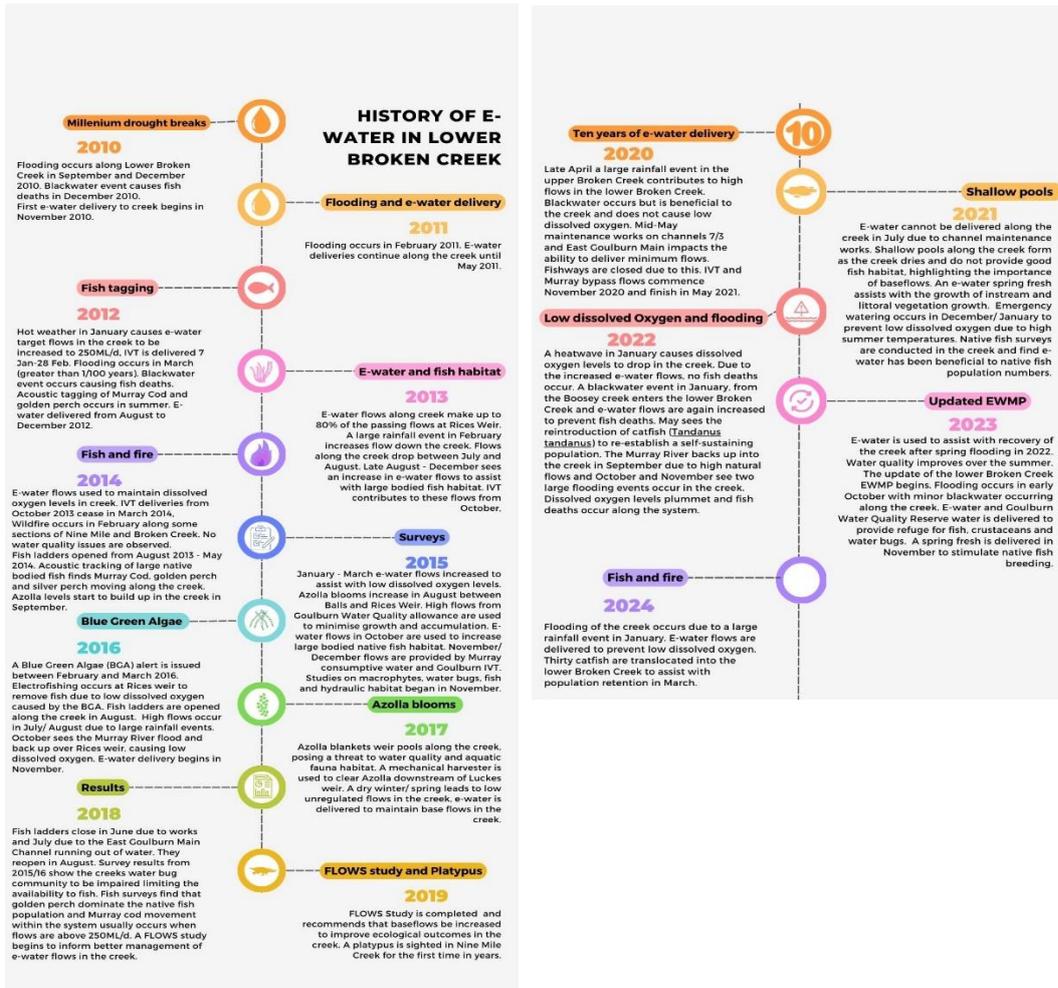


Figure 8: Timeline of Environmental Water deliveries and occurrences along lower Broken Creek and Nine Mile Creek since 2010

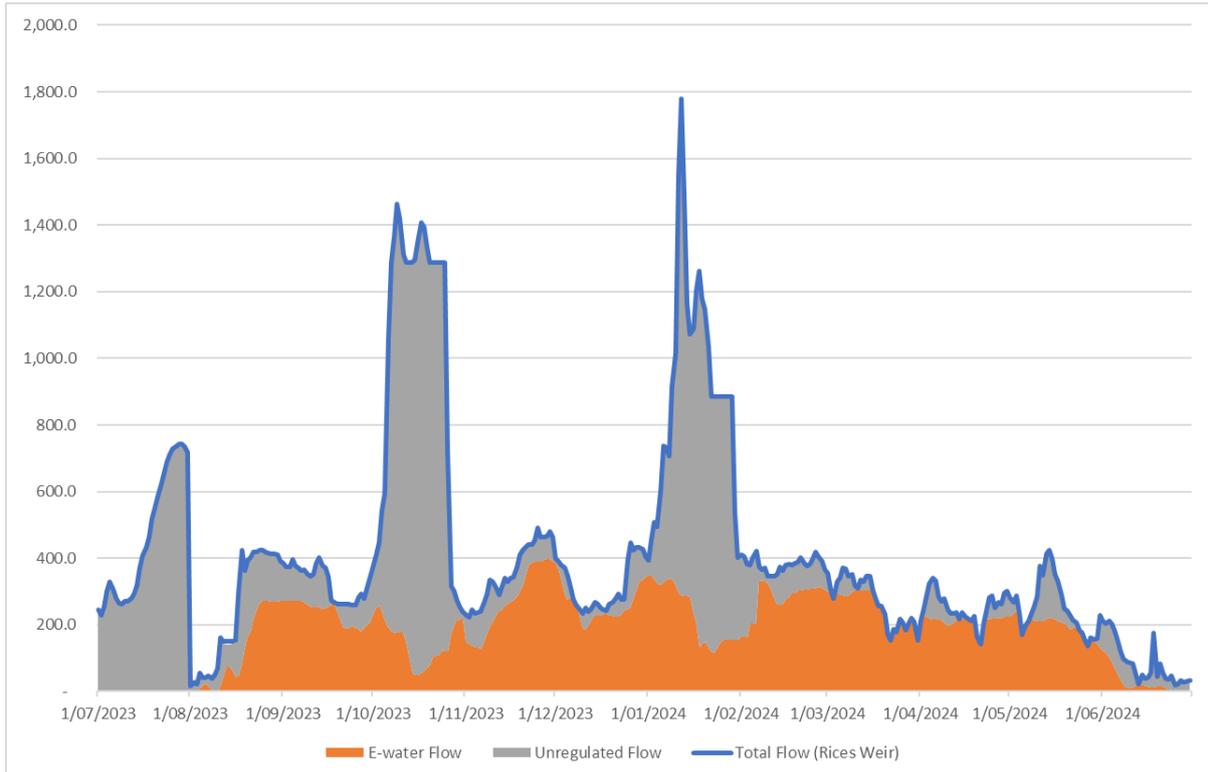
Outside of the irrigation season (15 May-15 August), it is often not possible to deliver environmental water from the Murray River or Goulburn River due to irrigation channel maintenance. Winter flow in the creek is therefore typically limited to unregulated inflows from the upper Broken Creek or Boosey Creek in response to rainfall. This means flow at Rices Weir can be very low or cease entirely, with the only remaining habitat occurring in the weir pools. The outcome is a reversed flow regime with higher flows in spring to autumn and low flows in winter.

The lower Broken and Nine Mile Creek can naturally flood in winter/spring during wet years, if large unregulated inflows occur from the upper catchment. Floods typically occur two to three times per decade, with flooding occurring in 2012, 2016, 2022, 2023 and 2024. Figure 10 shows the contribution of both unregulated flows and Environmental Water flows during 2023-24 when flooding occurred.

Groundwater has had a limited role in the hydrology of lower Broken Creek and Nine Mile Creek in recent times. Bore monitoring shows the water table has been 4-6m below natural surface level over the past five years.



Figure 9: Recent hydrological regime for the lower Broken Creek and Nine Mile Creek system



Figures 10: Example of unregulated and environmental water flow contribution to lower Broken Creek and Nine Mile Creek during a year which experienced two flood events.

3 WATER-DEPENDENT VALUES

3.1 ENVIRONMENTAL VALUES

The highly modified ‘novel ecosystem’⁵ (Figure 11) of the lower Broken Creek and Nine Mile Creek contains and provides a range of water-dependent environmental values. Many of these are a function of the altered (post-European) environment and are supported by the more permanent, regulated water regime. Despite this, the environmental values are significant, including several threatened native species and provision of critical habitat refugium in the landscape during periods of drought. Some of the environmental values are within the scope of influence of regulated environmental water deliveries, while others rely on larger natural unregulated flows, due to the current constraints in delivering environmental water outside the main waterway channel (Section 7).

A selection of water-dependent environmental values that are influenced by environmental water deliveries and are indicative of broader waterway health have been chosen as the focus of environmental water management at the site (Table 8). These include:

- Geomorphology.
- Refugium and connectivity.
- Water quality.
- Native vegetation.
- Native fish.
- Native turtles, rakali and platypus.

Each of these environmental values is described further in this section including its current condition and links to the Basin Plan. It is acknowledged that environmental water deliveries will provide direct and indirect shared benefits to a wide range of other environmental values within the creek system and broader landscape. Examples of these multiple values, their interactions with each other and with creek flow is provided in the below conceptual image.

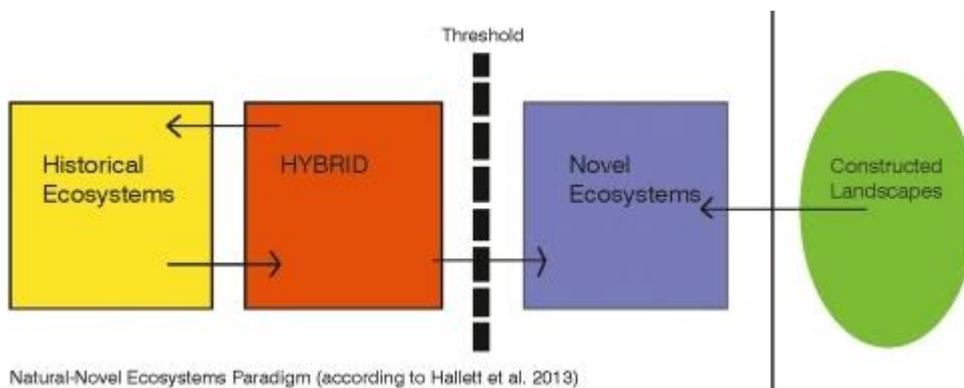


Figure 11: A concept diagram of a novel ecosystem (Hobbs. R 2006)

⁵ Novel ecosystem – river altered by regulation, altered flows and invasive species

Table 8: Water-dependent environmental values and their hydro-ecological interactions

Value	Regulated hydrology (flow/water level) influences	Directly influences	Focus for environmental water management in lower Broken Creek and Nine Mile Creek?
Geomorphology	Bank erosion. Bank deposition. In-channel siltation. In-channel scour. Physical form of the channel. Connection of the waterway to the floodplain.	Vegetation. Water quality. Habitat quality for aquatic biota e.g. substrate for macroinvertebrates, adequate depth for large-bodied fish.	Yes - the creek's physical form and processes are directly influenced by flow (and water level) and in turn influence the ecology, including components of the Basin Plan.
Refugium and connectivity	Availability and quality of refuge habitat. Longitudinal connectivity.	Vegetation. All creek associated fauna.	Yes – refugium during drought and longitudinal connectivity are components of the Basin Plan and some of the key functions lower Broken Creek and Nine Mile Creek performs in the broader landscape. The availability and quality of refugia/connectivity influences the ecology of the creek system and some ecological elements of the broader landscape.
Water quality	Dissolved oxygen. Carbon and nutrient concentration/load. Blue-green algal blooms. <i>Azolla</i> accumulations. Refuge availability during hypoxic Blackwater events.	Vegetation. All aquatic biota.	Yes – water quality in the creek is directly influenced by flow and in turn influences the ecology. Water quality is a component of the Basin Plan.
Vegetation (In channel, water margin, riparian zone)	Plant functional groups. Species diversity. Distribution and cover. Plant health. Growth, flowering, seed setting. Spread of propagules. Germination and recruitment.	Macroinvertebrates. Herbivorous biota. Fauna that uses vegetation for shelter and nesting e.g. waterbirds, small-bodied fish. Water quality e.g. nutrient uptake.	Yes – native vegetation is a key food source and habitat within and along the creek and helps stabilise bank sediments. It is directly influenced by the creek's hydrology. Threatened listed vegetation species and ecological communities are present (and are a component of the Basin Plan).
Fish	Habitat type and availability. Longitudinal connectivity. Species diversity and abundance?	Vegetation and macroinvertebrates – consumption. Many native fauna – food source.	Yes – fish are directly influenced by flow (and water level) and are an important food source for other native fauna. A healthy native fish community is an indicator of a healthy waterway as adequate conditions and food needs to be available to support diverse, abundant and successfully recruiting populations. There are several listed fish species in lower Broken and Nine Mile Creek (which are a component of the Basin Plan).
Turtles	Habitat type and availability. Species diversity and abundance.	Vegetation and macroinvertebrates – consumption. Some aquatic biota – food source e.g. Rakali, Murray cod.	Yes – turtles will be supported if adequate refugium is present, so will be managed through refugium management. This could include the Eastern snake-necked turtle (<i>Chelodina longicollis</i>) and the listed Murray River turtle (<i>Emydura macquarii</i>) and broad shelled turtle (<i>Chelodina expansa</i>), although records are limited for the creek.
Rakali (water rat)	Habitat type and availability	Vegetation and most aquatic biota – consumption.	Yes – Rakali will be supported if adequate refugium is present, so will be managed through refugium management. Rakali are not a listed species.
Platypus	Habitat type and availability	Macroinvertebrates – consumption.	Yes – lower Broken Creek and Nine Mile Creek provide very marginal habitat for platypus due to the shallow depths, shallow banks (poor nesting habitat) and limited refuge pools over winter. There are limited historic platypus records and no confirmed sightings in recent years, indicating likely absence of the listed species. If platypus do occur, they will be supported through refugium management such as maintaining flow conditions which is a key requirement for the species.

3.1.1 Geomorphology

Lower Broken Creek and Nine Mile Creek are lowland streams with a low gradient, historically part of the Broken River system. Since European settlement, these creeks have undergone significant changes due to human activities including the construction of weirs, levees, channel dredging, realignments, and the removal of natural vegetation and habitat like fallen trees.

Historic modifications include:

- Channelization of 32 km downstream of Shepparton Irrigation District Drain 12.
- Removal of Typha to maintain flow capacity between Katandra Weir and Nine Mile Creek.
- Grading and dredging that lowered the creek bed by up to one meter between Nine Mile Creek and Nathalia Town Weir, along with the removal of snags.

These changes have led to channel incision, bank erosion, and sediment accumulation. The creeks now exhibit poor physical conditions with deep notches and overhanging ledges due to ongoing erosion exacerbated by increased water flow from irrigation practices and weirs (Figure 12). This erosion has resulted in extensive sediment accumulation in some areas and a reduction in geomorphic diversity.

Despite these changes, the physical form of the creeks still impacts their ecological value. Key features include:

- **Creek Bed:** A mix of mud/silt over clay, supporting aquatic macrophytes and benthic macroinvertebrates. Channel widening and shallowing from bank erosion have altered habitat availability.
- **In-channel Benches:** Shallow sediment shelves that support riparian plant growth and provide habitat for various aquatic species.
- **Pools:** Limited natural deep pools exist, but weir pools and artificially created pools serve as important habitats for large fish and diving waterbirds.
- **Banks:** Generally shallow with some areas of steeper bank. Eroding banks support less vegetation, increasing erosion, while stable banks support diverse riparian growth.

Overall, the physical form of the creeks influences sediment dynamics, habitat availability, and the types of flora and fauna that can be supported.



Figure 12: Examples of geomorphological changes along lower Broken Creek (Top left – reduced bed diversity; top right – bank erosion leading to notching, photo by C. Bourke; bottom – channel widening, photo by Streamology 2021)

3.1.2 Refugium and connectivity

The lower Broken Creek and Nine Mile Creek system benefits from a highly regulated water regime, ensuring a reliable water supply from the Murray and Goulburn Rivers, as well as inflows from other local creeks. This system maintains high water security throughout the year, with the highest flow reliability during the irrigation season (15 August-15 May). The presence of multiple weir pools helps control water levels, providing a crucial refugium during droughts, as seen at the end of the Millennium drought when parts of upper Broken Creek dried out.

The system supports diverse aquatic and riparian species by offering refuge habitats with varying conditions:

- **Irrigation Season:** The entire 196 km of the creek system has permanent water, with flowing habitats in reaches 1-3 and still water habitats in reach 4. Refuge depth varies from less than one meter in reach 1 to one to two meters in reach 4.
- **Winter:** Flow may be limited due to irrigation channel maintenance, causing the creek to contract to weir pools. These pools become essential habitats for fish, turtles, and rakali during this period, attracting piscivorous waterbirds.

Fishways on the nine weirs facilitate connectivity between the Murray River and the Broken/Boosey Creek system, crucial for the migration of native fish like Murray cod and golden perch. Environmental water deliveries are vital for maintaining fishway operation and creek connectivity, especially during warm months. However, low winter flows can temporarily close fishways, affecting connectivity.

These features align with the Basin Plan by ensuring:

- **Ecosystem Function:** Fishways support aquatic biota by maintaining longitudinal connectivity.
- **Ecosystem Resilience:** The system provides drought refuge due to reliable water security and reduced fragmentation.
- **Priority Environmental Asset (PEA) Criteria:** The ecosystem offers vital habitat and pathways for dispersal and migration.
- **Priority Ecosystem Function (PEF) Criteria:** Environmental watering is crucial for maintaining vital habitats and connections along the watercourse.

3.1.3 Water quality

Water quality data for lower Broken Creek and Nine Mile Creek is limited, making comprehensive assessments challenging. Available data and historical monitoring indicate generally poor water quality in the lower Broken Creek and Nine Mile Creek, characterised by:

- **Hypoxic Events:** Frequent occurrences of hypoxic (0-2 mg/L dissolved oxygen) blackwater, particularly after intense summer rainfall or natural flooding events, such as those in February and spring 2022 (Figure 13).
- **High Turbidity:** Long-term average turbidity at Rices Weir is 108 ± 3 NTU, with peaks exceeding 400 NTU. This is significantly higher than the Australian & New Zealand Guidelines for Fresh and Marine Water Quality (ANZECC and ARMCANZ 2000) range of 6-50 NTU for lowland rivers in southeastern Australia.
- **High Nutrient Levels:** Nutrient concentrations exceed the water quality guidelines, contributing to high risks of blue-green algal blooms and excessive Azolla growth. These conditions can lead to hypoxic environments when algae and plants decay.

Eutrophic Water Quality Values at Rices Weir:

- **Nitrogen Oxides (NO_x):** 0.093 ± 0.008 mg/L (guideline: 0.040 mg/L)
- **Total Nitrogen (TN):** 1.47 ± 0.040 mg/L (guideline: 0.500 mg/L)
- **Total Phosphorus (TP):** 0.347 ± 0.014 mg/L (guideline: 0.050 mg/L)
- **Filtrable Reactive Phosphorus (frP):** 0.068 ± 0.005 mg/L (guideline: 0.020 mg/L)

These indicators highlight ongoing water quality issues in the creek system.



Figure 13: Hypoxic blackwater vs highly turbid water in the lower Broken Creek

3.1.4 Flora – Bioregions and Ecological Vegetation Classes

Lower Broken Creek and Nine Mile Creek is situated in the Victorian Riverina and Murray Fans bioregions. Bioregions are a landscape-scale approach to classifying the environment using a range of attributes such as climate, geomorphology, geology, soils and vegetation (Figure 14). Victorian Riverina, located north of the Great Dividing Range in Victoria is characterised by flat to gently undulating landscape on recent unconsolidated sediments with evidence of former stream channels and wide floodplain areas associated with major river systems and prior streams. Alluvium deposits from the Cainozoic period (65 million years – present day) gave rise to the red brown earths and texture contrast soils (Chromosols and Sodosols) which dominate the Riverine Plain. Annual average rainfall for the region ranges from 360-672mm per annum. The average minimum and maximum temperature range is from 3°C to 9°C and 15°C to 21°C respectively. The vegetation is dominated by Plains Grassy Woodland, Plains Grassland, Pine Box Woodland/Riverina Plains Grassy Woodland Mosaic, Riverine Grassy Woodland/Riverine Sedgy Forest/Wetland Mosaic, Plains Grassy Woodland/Gilgai Plains Woodland/ Wetland Mosaic, Grassy Woodland and Wetland Formation ecosystems. The Victorian Riverina bioregion is associated with the eight river basin tributaries of the Murray River draining north, west, and southwest from the Great Dividing Range of eastern Australia (DELWP 2022).

Murray Fans, located in north central Victoria, is characterised by a flat to gently undulating landscape on recent unconsolidated sediments with evidence of former stream channels, braided old river meanders and palaeochannels and broad floodplain areas associated with major river systems and prior steams (known as braided / anastomosing streams). Alluvium deposits from the Cainozoic period gave rise to the red brown earths and texture contrast soils (Chromosols and Sodosols). The vegetation is a mosaic of Plains Grassy Woodland, Pine Box Woodland, Riverina Plains Grassy Woodland and Riverina Grassy Woodland ecosystems. The bioregion covers the margins of six separate drainage basins; the Broken River, Goulburn River, Campaspe River, Loddon River, Avoca River and the Mallee (DELWP 2022).

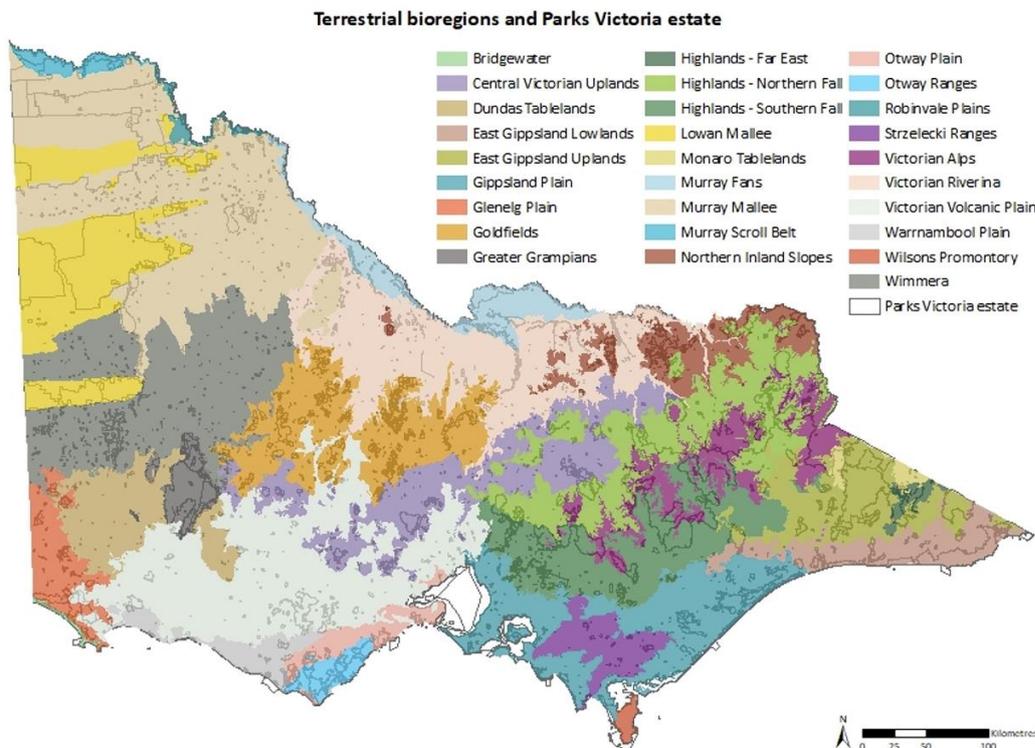


Figure 14: Map of Victorian Bioregions

The lower Broken Creek and Nine Mile Creek occur along both the Victorian Riverina and Murray Fans bioregions, of which there are two dominant Ecological Vegetation Classes (EVC) (indicated in bold in Table 9) along the waterway frontage, including:

- EVC 68 – Creepline Grassy Woodland is dominant throughout all reaches.
- EVC 803 – Plains Woodland occurs commonly on the broader floodplain but occupies substantial lengths of stream frontage in Reaches 3 and 4.

Narrow fringes of box-dominated grassy woodland line the creeks with Grey Box, the occasional Yellow Box, River Red Gum and Buloke (PV 2006). River Red Gum is more closely associated with the riparian zone closest to the waterways of upstream reaches with Grey Box associated with drier parts of the floodplain and downstream reaches.

EVC 68 is likely to be directly affected by changes in in-channel flows while and EVC 803 is less likely to be influenced by high level in-channel flows (WT 2016). However, neither of these EVCs are flood dependent. EVCs 68 and 803 are listed as endangered vegetation communities (Cottingham and SKM 2011) with their ranges restricted to <10% and severely degraded.

Based on 2004 Index of Stream Condition the riparian condition assessed was average to good, with a mature overstorey (often regrowth) but degraded understorey (reduced structural complexity, reduced species richness, little or no recruitment and an understorey of non-native species) (Hale, Roberts et al. 2006). Although Index of Stream Condition was not undertaken as part of this revision, the assessment by Hale et al. (2006) is likely to reflect current condition (Jacobs 2019).

Table 9: Conservation status of EVCs along lower Broken Creek and Nine Mile Creek

EVC	EVC name	Bioregional conservation status ⁶	Occurrence in each reach
56	Floodplain Riparian Woodland	Depleted (2)	Reach 4
68	Creepline Grassy Woodland	Endangered (1)(2)	Reach 1, 2, 3 and 4
106	Grassy Riverine Forest	Depleted	Reach 4
125	Plains Grassy Wetland	Endangered (1)(2)	Reach 3 and 4
264	Sand Ridge Woodland	Endangered (1)(2)	Reach 4
292	Red Gum Swamp	Vulnerable (1)	Reach 2
295	Riverine Grassy Woodland	Vulnerable (1)(2)	Reach 4
803	Plains Woodland	Endangered (1)(2)	Reach 1, 2, 3 and 4
814	Riverine Swamp Forest	Depleted (1)(2)	Reach 4
816	Sedgy Riverine Forest	Vulnerable (1) and Depleted (2)	Reach 4
882	Shallow Sands Woodland	Endangered (1) and Vulnerable (2)	Reach 3 and 4

⁶ (1) denotes Victorian Riverina Bioregion and (2) denotes Murray Fans Bioregion

Native vegetation along the lower Broken Creek and Nine Mile Creek is essential for the creek's health and ecosystem function. It contributes to:

- **Instream Productivity:** Supports phytoplankton growth and provides organic matter.
- **Food Provision:** Supplies food for herbivorous waterbirds through aquatic macrophytes.
- **Shelter:** Offers habitat for fish, frogs, and waterbirds.
- **Nesting:** Provides materials and locations for species like Rakali.
- **Bank Stabilisation:** Helps prevent erosion.
- **Water Quality:** Enhances oxygenation and nutrient uptake.
- **Temperature Regulation:** Provides shade to regulate water temperature.
- **Habitat:** Supplies woody material, such as snags, for fish like Murray cod and golden perch.

The vegetation can be categorised into three types:

1. **In-Channel Vegetation:** Includes species like Cumbungi, Ribbonweed, and Common Reed. It lacks diversity due to altered flow regimes and the impact of carp, which reduce vegetation and increase turbidity.
2. **Water Margin Vegetation:** Comprises flood-tolerant species along the creek's edges. The condition varies, often dominated by a few species, and is directly influenced by hydrology.
3. **Riparian Vegetation:** Dominated by Ecological Vegetation Classes such as Creepline Grassy Woodland and Plains Woodland. This vegetation faces threats from altered flow regimes but is less affected by high in-channel flows.

Vegetation Condition:

- **In-Channel:** Generally, lacks diversity. Abundant in some areas but degraded due to changes in flow and turbidity.
- **Water Margin:** Limited eucalyptus overstorey and variable conditions. Bank stabilization and food provision are key functions.
- **Riparian Zone:** Includes endangered and vulnerable Ecological Vegetation Classes. The condition varies from average to good, with a mature overstorey but a degraded understorey.

Wetlands:

- Small floodplain wetlands exist but are rarely inundated by creek flows. Notable wetlands like Kinnairds and Black Swamp host rare and threatened species, with a separate environmental management plan for these wetlands.

Overall, the vegetation plays a crucial role in maintaining the creek's ecological health and stability, supporting a range of native species and ecosystem functions.

3.1.4.1 Threatened Flora

Most plant species in the lower Broken Creek and Nine Mile Creek are not threatened, though significant populations of vulnerable and endangered species, like Ridged Water Milfoil and Slender Water Milfoil, are found at Kinnairds Swamp. Table 10 identifies the EPBC Act and FFG Act listed species only. Nineteen threatened flora species associated with waterways have been identified, with three being aquatic, 14 near water margins, and two requiring seasonal flooding (Appendix C).

Table 10: EPBC Act listed species found in and along the lower Broken Creek and Nine Mile Creek

Scientific name	Common name	EPBC status	FFG status	Reach
<i>Amphibromus fluitans</i>	River Swamp Wallaby-grass	V	k	Reach 3 and 4
<i>Brachyscome muelleroides</i>	Mueller Daisy	V	e	Reach 1, 2, 3 and 4
<i>Callitriche cyclocarpa</i>	Western Water-starwort	V	v	Reach 3 and 4
<i>Cardamine paucijuga s.s.</i>	Annual Bitter-cress		v	Reach 1, 2, 3
<i>Cullen parvum</i>	Small Scurf-pea	E	e	Reach 3 and 4
<i>Myriophyllum porcatum</i>	Ridged Water-milfoil	V	v	Reach 1, 2, 3 and 4
<i>Swainsona murrayana</i>	Slender Darling-pea	V	e	Reach 3 and 4
<i>Swainsona recta</i>	Mountain Swainsona-pea	E	e	Reach 3 and 4

Legend: EPBC Act status: Endangered (E), Vulnerable (V)

FFG Act status: Endangered (e), Vulnerable (v), Poorly known (k)

Vegetation in the lower Broken Creek and Nine Mile Creek is degraded due to regulated flow regimes that differ from natural conditions, resulting in stable but poor vegetation health. This stability, combined with factors like channel form, livestock grazing, and exotic species, impacts vegetation condition. The system's current state makes it vulnerable to extreme flow changes, which may be exacerbated by climate change.

Despite modifications, the vegetation still supports local biodiversity. In-channel and riparian vegetation are in fair condition but show declining quality upstream and in eroding bank areas. Downstream, some good quality riparian vegetation exists, with limited changes expected under the current flow regime.

3.1.5 Fauna

The lower Broken Creek and Nine Mile Creek supports several native water-dependent fauna species. There have been no targeted fauna surveys for many years and the list of possible species (Appendix D) is based on historic work, with subsequently a low degree of confidence e.g. Biodiversity Action Planning (Heard 2007, DSE 2008) and waterway management strategies (GHD and URS 2005).

While these species are an important part of the creek’s ecology, they were not originally chosen as a specific focus for environmental water management at the site, as:

- Many are not of conservation significance e.g. are not listed threatened species.
- The presence and distribution of most species is unknown. Some species may no longer be present.

Their collective, general hydrological and habitat requirements can instead be reflected through management of refugium, connectivity, vegetation and fish. Platypus, Rakali and Turtles have been added to the Environmental objectives for the updated Plan to assist with the hope of movement and population increases of these species into the lower Broken Creek and Nine Mile Creek system.

3.1.5.1 Native fish

Fish populations in the lower Broken Creek and Nine Mile Creek have been extensively studied over the past 10-15 years, revealing a diverse native fish community. However, data on Nine Mile Creek (Reach 2) and upper reaches of the lower Broken Creek (Reach 1) is limited, with monitoring only recently starting. Prior to 2021, monitoring focused mainly on the lower reaches due to fishway installation for weirs between Nathalia and the Murray River. In the lower Broken and Nine Mile Creeks, seven native fish species of conservation significance have been recorded, including Murray Cod, silver perch, and trout cod, all protected under the EPBC Act (Table 11).

Table 11: Native fish species of the lower Broken and Nine Mile Creeks

Common Name	Scientific Name	EPBC Act listing	FFG Act listing	Reaches present
Australian smelt	<i>Retropinna semoni</i>			1,2,3,4
Bony bream	<i>Nematalosa erebi</i>			unknown
Carp gudgeon	<i>Hypseleotris spp.</i>			1,2,3,4
Flathead gudgeon	<i>Philypnodon grandiceps</i>			1
Freshwater catfish	<i>Tandanus tandanus</i>		Endangered	unknown
Golden perch	<i>Macquaria ambigua</i>		Vulnerable	1,3,4
Murray cod	<i>Maccullochella peelii</i>	Vulnerable	Endangered	1,2,3,4
Murray-Darling rainbowfish	<i>Melanotaenia fluviatilis</i>		Endangered	2,3,4
River blackfish	<i>Gadopsis marmoratus</i>		Critically Endangered	unknown
Silver perch	<i>Bidyanus bidyanus</i>	Critically Endangered	Endangered	1,4
Trout cod	<i>Maccullochella macquariensis</i>	Endangered	Endangered	4
Unspecked hardyhead	<i>Craterocephalus stercusmuscarum fulvus</i>			4

Recent fish surveys indicate a significant decline in fish populations within the creek system, largely due to a severe hypoxia/blackwater event in late October 2022. This event led to the death of several fish species, including Murray cod, golden perch, and European carp. Subsequent surveys have shown a dramatic decrease in fish numbers:

- **Murray cod:** Only one was caught in the past two surveys.
- **Golden perch:** Numbers dropped from 49 in 2022 to just 3 in 2024.
- **Other species:** No Silver perch, river blackfish, or trout cod were recorded in the 2023 and 2024 surveys. One Silver Perch was recorded in 2025 (see fig below).
- **Australian smelt** and **Murray-Darling rainbowfish** populations have significantly decreased, with only 26 and 3 recorded in 2024, respectively.

- **European carp:** Their numbers also dropped significantly in 2024 (682) compared to 2023 (2301).

The data suggests that the blackwater event and subsequent less severe events have severely impacted fish populations. Recovery and conservation efforts, including the delivery of environmental water, functioning fishways, and sufficient winter and spring flows, are crucial to support the recovery of native fish populations and mitigate the impacts of poor water quality.



Figure 15: Silver Perch sampled in fish surveys conducted in 2025

3.1.6 Other Fauna values

The lower Broken Creek and Nine Mile Creek retain small, fragmented patches of original vegetation in a largely cleared landscape. These remnants are vital for supporting threatened flora and fauna, some of which may be affected by changes in hydrology.

In Victoria, threatened species are listed under two primary acts:

- The ***Victorian Flora and Fauna Guarantee Act 1988 (FFG Act)***, which consolidates previous lists into a single comprehensive list.
- The ***Environment Protection and Biodiversity Conservation Act 1999 (Cth)***, a federal legislation.

Rakali (water rats) are frequently sighted along the creeks, and therefore considered important to ensure watering actions support their ecological needs. Historic records indicate the presence of Platypus within the lower Broken Creek and Nine Mile Creek. However, they have not been observed in decades.

Historic records suggest up to twenty significant listed species may be associated with these waterways. The focus of management efforts is on maintaining refuges, connectivity, and vegetation to support these species collectively (Appendix D).

3.2 SHARED BENEFITS

Water for the environment is used to protect and restore the environmental condition of rivers and wetlands. In addition, there are recreational, social, economic, and Traditional Owner benefits in delivering environmental water. Environmental watering of rivers increases opportunities and visitation for community events, fishing, bird watching, picnicking, photography, walking, camping, and hunting. Rivers provide resources for Yorta Yorta People for hunting, food, medicinal and traditional activities.

3.2.1 Yorta Yorta cultural values

Traditional Owners value water in the landscape's waterways and wetlands as a way of caring for country, for supporting culturally important plants and providing opportunities to practice culture. Yorta Yorta Nation Aboriginal Corporation is the Registered Aboriginal Party (RAP) for the lower Broken Creek and Nine Mile Creek system, under the *Aboriginal Heritage Act* (2006).

During consultation with Yorta Yorta Nation Aboriginal Corporation in previous years the following cultural values have been identified for the lower Broken Creek and Nine Mile Creek:

“The Broken Creek holds many cultural values. Common reed contained within the slack water provides important material for tools whilst also providing refuge for culturally important fish species (large & small bodied). The creek also has significant stands of old growth river red gum containing important habitat and exhibiting scars made from carving out canoes and coolamons” (J. Whittaker, pers. comm. 4 March 2021).

The Yorta Yorta Whole of Country Plan 2021-2030 (YYNAC 2021) includes Broken Creek as a priority place with high value including native fish populations, turtles, platypus, rakali, and the EPBC Act listed Australasian bittern and River swamp wallaby grass. Threats around inadequate flow leading to low oxygen levels and overabundant *Azolla* are identified. The Plan outlines Walla (water) actions to “achieve healthier Country and better outcomes for ecosystems and native plants and animals” including improving “volumes, seasonality, timing and depth of river flows” and “the cultural and environmental outcomes from watering operations.” This includes protecting “culturally important animal species, especially turtles, through measures to conserve land and water habitat.”

The watering objectives of this plan align with Yorta Yorta values of caring for Country (Section 5.3). Flows have been specifically targeted to support instream vegetation and native fish, along with other aquatic biota. The Goulburn Broken CMA and other relevant agencies will continue to work with Yorta Yorta Nation Aboriginal Corporation to identify how environmental water management can best support cultural values.

3.2.2 Recreational values

The lower Broken Creek and Nine Mile Creek have a high recreational value. The creeks are accessible for fishing, canoeing and passive recreation. Delivery of water for the environment has helped support these activities e.g. through providing baseflows that keep fishways operational as well as freshes that provide movement and spawning cues for key species such as Murray cod. Water for the environment is also critical for maintaining good water quality in the creek, azolla movement and particularly following natural flood events that can be associated with hypoxic blackwater and pungent odour.

4 CURRENT CONDITION

4.1.1 Overview of ecological condition

The condition of lower Broken and Nine Mile Creek was assessed in the 2010 Third Benchmark Report using the Index of Stream Condition (DELWP 2020). This index evaluates hydrology, streamside zone, physical form, water quality, and aquatic life. The overall ISC score for these creeks ranged from poor to moderate, with hydrology, water quality, and aquatic life rating lower than physical form and streamside zone.

Since 2010, no additional Index of Stream Condition assessments have been conducted, but other investigations provide insights into the current condition. The flow regime in these creeks now experiences high flows during the irrigation season and very low flows in the non-irrigation season, leading to habitat contraction and isolation, which negatively impacts macroinvertebrates, fish, platypus, and rakali. This lack of winter flows and pool drawdown is a critical factor in the poor diversity of macroinvertebrate and fish communities in certain reaches.

Additionally, the creeks are increasingly used for water conveyance, including Inter-Valley Trade flows and bypass flows, which may exacerbate the effects of unseasonal high flows on bank conditions. Monitoring efforts conducted as part of the Goulburn to Murray Trade rule review in autumn/winter 2022 assessed bank condition, vegetation, and fish populations and are part of ongoing water quality and flow monitoring to inform management decisions. The latest monitoring data, combined with observations from the October 2022 flood, are used to outline the current ecological condition and the trajectory of change.

4.1.2 Trajectory of change

The lower Broken and Nine Mile Creeks have generally been in poor to moderate condition, facing issues such as poor water quality, fish deaths, erosion, siltation, and azolla accumulation. Despite these problems, native fish species like Murray cod and Golden perch are present.

Key findings include:

- **Geomorphology:** Poor condition due to historical modifications regulated flows and weirs leading to low complexity in features and habitat, ongoing bank erosion, and siltation of the bed.
- **Native Fish:** Moderate condition, with a mix of native and exotic species. Stocking helps maintain populations, but habitat quality issues persist, particularly in Reach 3.
- **Vegetation:** Poor condition, with regulated flow regimes favouring certain robust species and degraded riparian zones due to grazing and timber removal.
- **Macroinvertebrates:** Poor condition, with low diversity and abundance, particularly downstream of Numurkah, affected by poor habitat quality and pollutants.
- **Water Quality:** Poor condition, with turbidity and eutrophic conditions. Reach 4 experiences hypoxic events and azolla accumulations, leading to fish deaths, though some improvements in water quality have been noted.

The system's condition is expected to decline or remain stable if a “do nothing” approach is taken. This will include ongoing erosion and siltation which will continue to impact ecological values.

4.2 MANAGING THREATS AND RISKS

The water-dependent environmental values of the lower Broken and Nine Mile Creeks are vulnerable to several key threats, necessitating an integrated approach to manage these risks. Potentially threatening processes identified in the FFG Act (DELWP 2022) relevant to delivering environmental water in the lower Broken Creek and Nine Mile Creek include:

Delivery of environmental water along the lower Broken Creek and Nine Mile Creek can be constrained by:

Irrigation demands: Channel capacity for environmental water deliveries may be limited during peak irrigation season. Demands on input systems to the creek such as the Goulburn and Murray rivers may also impact upon environmental water delivery to the system. High demands may also lead to unwanted elevated flows in the system which may impact lower bank vegetation.

Winter works: Channels used to deliver environmental water along the lower Broken Creek and Nine Mile Creek may be closed over winter for maintenance.

Risks and threats can present in many forms including climate, environmental, community, management, cultural and legal risks. Potentially threatening processes listed in the FFG Act and are relevant to the delivery of environmental water and this plan include:

Altered Flow Regime: Alteration of the natural flow regimes of rivers and streams.

Degraded Riparian Vegetation: Loss and degradation of native vegetation along riverbanks.

Increased Sediment Input: Increase in sediment input into Victorian rivers and streams due to human activities.

Invasive Species: Invasion of native vegetation by environmental weeds and fauna species such as Carp.

Restricted Passage: Barriers preventing the movement of aquatic life due to instream structures.

Loss of in-stream habitat: Removal of wood debris from Victorian streams.

Issues not identified in the FFG Act (DELWP 2022) but is important to note for the lower Broken Creek and Nine Mile Creek are:

Poor Water Quality: Events that impact dissolved oxygen levels and water temperature such as azolla accumulation, heatwaves, and hypoxic blackwater.

Loss of physical habitat features: Loss of geomorphic diversity such as deep pools, benches and bars due to river regulation.

Constraint to delivery from weirs: Weirs limit the amount of water that can be pushed through the system and the continuity of the movement of the water.

Climate change exacerbates these threats, with projections indicating more extreme weather, reduced rainfall, longer droughts, and increased fire risks. This will likely result in less water availability, higher water treatment costs, degraded aquatic ecosystems, and loss of habitat for flora and fauna (CSIRO 2022).

To mitigate these threats, various measures are implemented, such as monitoring programs, planning and delivering environmental water, and managing invasive species. Detailed risk assessments and mitigation plans are developed prior to the delivery of environmental water to address potential environmental water delivery risks (Appendix F).

The key threats to the water-dependant values of lower Broken Creek and Nine Mile Creek are outlined further in Table 12 along with the potential mitigation measures.

Table 12: Identified threats and mitigation actions

Water related threat	Description	Likelihood	Consequence	Risk	Mitigation Measures
Altered flow regime	Creek flows changed to high summer flows and low winter flows.	Likely			Environmental water base flows delivered in winter months to retain flow and pools.
Increased sediment input	From channels? Or after fire and flood events?	Possible	Major	High	Provide refuge by delivering water through outfalls and assist with movement of suspended sediments from fire or floods.
Invasive species	Plants – such as arrowhead Animals – Carp	Likely	Moderate	Medium	Plants – Spray programs to control and eradicate infestations. Carp eradication programs in the future may assist with population decrease.
Restricted passage	Weirs restricting fish and platypus movement	High	Major	High	Environmental water base flows delivered in winter months to retain flow and weir pools and prevent restricted passage for fauna.
Poor water quality	Azolla - a common free-floating fern, thrives in high nutrient conditions and can rapidly form dense mats. Excessive Azolla growth can impede water flow, reduce sunlight penetration, and cause deoxygenation upon die-off. Azolla build up may block access to some littoral habitats like backwater areas. Hypoxia - (dissolved oxygen (DO) levels fall below 2 mg/L, significantly increases the risk of crustacean and fish deaths). Can be caused by Blackwater events, sediment oxygen demand in weir pools, diurnal fluctuations from plants and algae and heatwaves. Heatwaves - Shallow depths and low flow velocities make the lower Broken Creek and Nine Mile Creek prone to low DO levels during heatwaves, with temperatures reaching up to 29°C, exacerbating hypoxia. Turbidity – caused by the introduction of Carp, sediment input from channels and bank erosion.	Possible	Major	High	Azolla - Environmental water deliveries in spring can help move Azolla buildup out of the system and provide oxygenated water to prevent fish deaths. Hypoxia – Environmental water deliveries can help maintain DO levels above 5 mg/L to support aquatic organisms. Heatwaves - Increased discharge is a known method to prevent deoxygenation at Rices Weir. Additionally, flows can serve as a source of oxygen. At 20°C, 100 ML of water at saturation contains approximately one tonne of oxygen, helping to offset oxygen depletion. Turbidity – Manage environmental water deliveries so a gradual rise and fall occurs to prevent bank erosion. Control Carp with possible introduction of herpes virus when available.
Water loss	Transition losses along the lower Broken Creek and Nine Mile Creek are unknown	Likely	Minor	Moderate	Review losses along lower Broken Creek and Nine Mile Creek. Allow for losses when

					estimating environmental water requirements.
Limited channel capacity	Releases to meet consumptive demand may constrain the capacity available for delivering environmental flows.	Possible	Minor	Medium	Risk may be offset by the delivery of consumptive water. GB CMA and Goulburn-Murray Water to undertake early planning and communication to identify and address potential channel capacity constraints.

5 MANAGEMENT GOALS, OBJECTIVES AND TARGETS

5.1 MANAGEMENT GOALS

The long-term vision for lower Broken Creek and Nine-Mile Creek has been derived from the Community Reference Group from the lower Broken Creek Waterway Management Strategy 2005 (GHD and URS 2005) and reflects:

“A healthy system that provides water for human and agricultural use, protects and enhances our social, economic and cultural values, and sustains a vibrant range and abundance of native flora and fauna.”

It is supported by the following Goulburn Broken CMA Waterway Strategy (GBCMA 2014) goals:

- Maintain or improve the resilience of the region’s waterways.
- Maintain or improve waterways of high community value.
- Populations of threatened aquatic dependent species will be maintained or improved - including trout cod, Murray cod, Freshwater catfish, golden perch and silver perch.

5.2 ENVIRONMENTAL OBJECTIVES AND TARGETS

Environmental objectives for the lower Broken Creek and Nine Mile Creek have been documented in a variety of formats across multiple strategies and plans since 2001. The current environmental objectives were developed through the recently completed lower Broken Creek FLOWS study (SKM 2002, Jacobs 2019), as summarised below, with further details developed for this Plan. Figure 15 shows the alignment of the Plan objectives to the three overarching environmental objectives of the Basin Plan Chapter 8 hierarchy and then to the relevant sections within Chapter 8 (S8.05, 8.06 and 8.07). Table 13 aligns overall goals for the lower Broken Creek and Nine Mile Creek to objectives and targets. A watering decision chart (Figure 16) has been devised to assist with individual reach management and targeting objectives and flows during different seasons.

Note: No targets have previously been developed for lower Broken Creek and Nine Mile Creek environmental water management

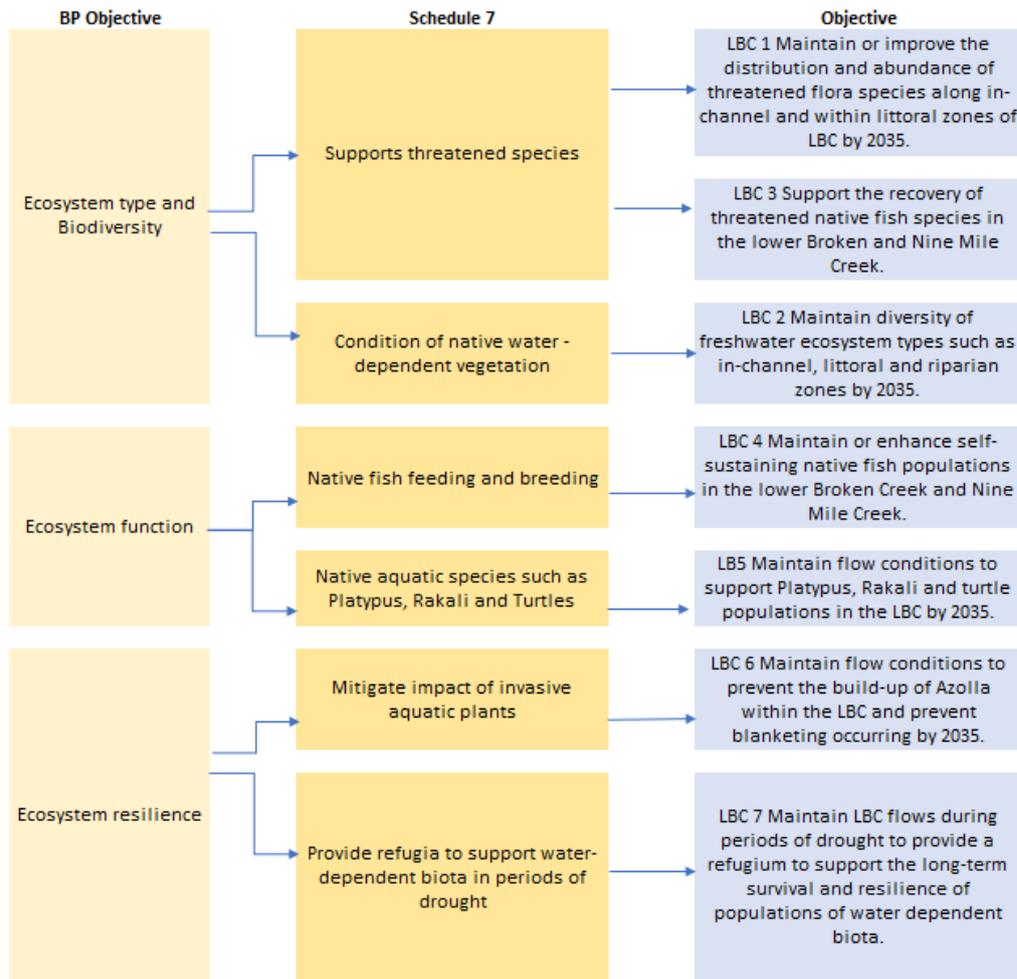


Figure 16: Alignment of lower Broken Creek and Nine Mile Creek objectives to the Basin Plan

Table 13: Objectives and targets for lower Broken Creek and Nine Mile Creek Plan

Goal	Objective	Target
To deliver environmental water which maintains instream and littoral zone vegetation.	LBC 1 Maintain or improve distribution and abundance of threatened vegetation species along in-channel and within littoral zones of lower Broken Creek and Nine Mile Creek by 2035.	By 2035, maintain or increase populations of listed aquatic plant species such as Slender Water Ribbons and Rigid Water Milfoil in the lower Broken Creek and Nine Mile Creek at 2022 levels.
To deliver environmental water which maintains instream and littoral zone vegetation.	LBC 2 Maintain diversity of freshwater ecosystem types such as in-channel, littoral and riparian zones by 2035.	By 2035, aquatic plant species diversity and abundance in lower Broken Creek and Nine Mile Creek is improved or maintained at 2022 levels (excluding post-flood events).
To deliver environmental water which improves recovery, resistance and resilience of native aquatic fauna.	LBC 3 Support the recovery of threatened native fish species in the lower Broken and Nine Mile Creek.	By 2035, the re-introduction of two threatened native fish species within the lower Broken Creek and Nine Mile Creek systems. Measured as re-introduction of two species (e.g. Freshwater Catfish, Southern Pygmy Perch, Flat-headed Galaxias), and species detections in subsequent surveys.
To deliver environmental water which improves recovery, resistance and resilience of native aquatic fauna.	LBC 4 Maintain or enhance self-sustaining native fish populations in the lower Broken Creek and Nine Mile Creek.	By 2035, the trajectory (catch per unit effort, species distribution, population structure) of key target species (Murray Cod, Murray-Darling rainbowfish and Australian Smelt) will be at or above 2024 levels.
To deliver environmental water which improves recovery, resistance and resilience of native aquatic fauna.	LBC 5 Maintain flow conditions to support Rakali, Platypus and turtle populations in the lower Broken Creek and Nine Mile Creek by 2035.	By 2035, show evidence that there has been movement of Platypus, Rakali and turtles into the lower Broken Creek and Nine Mile Creek. Maintain adequate weir pool depth to assist with foraging for food. Ensuring flows during Platypus breeding season have minimum impact on burrows.
To deliver environmental water which minimises the growth and impact of Azolla within the lower Broken Creek system.	LBC 6 Maintain flow conditions to prevent the build-up of Azolla within the lower Broken Creek and Nine Mile Creek and prevent blanketing occurring by 2035.	By 2035, prevent any Azolla blooms occurring.
To deliver environmental water to minimise the impact of drought, floods and fire on the lower Broken Creek system.	LBC 7 Maintain lower Broken Creek and Nine Mile Creek flows during periods of drought to provide a refugium to support the long - term survival and resilience of populations of water dependent biota.	Maintain flows at least 250ML/d during drought to provide refugium for water dependent species.

Which reaches are you targeting?

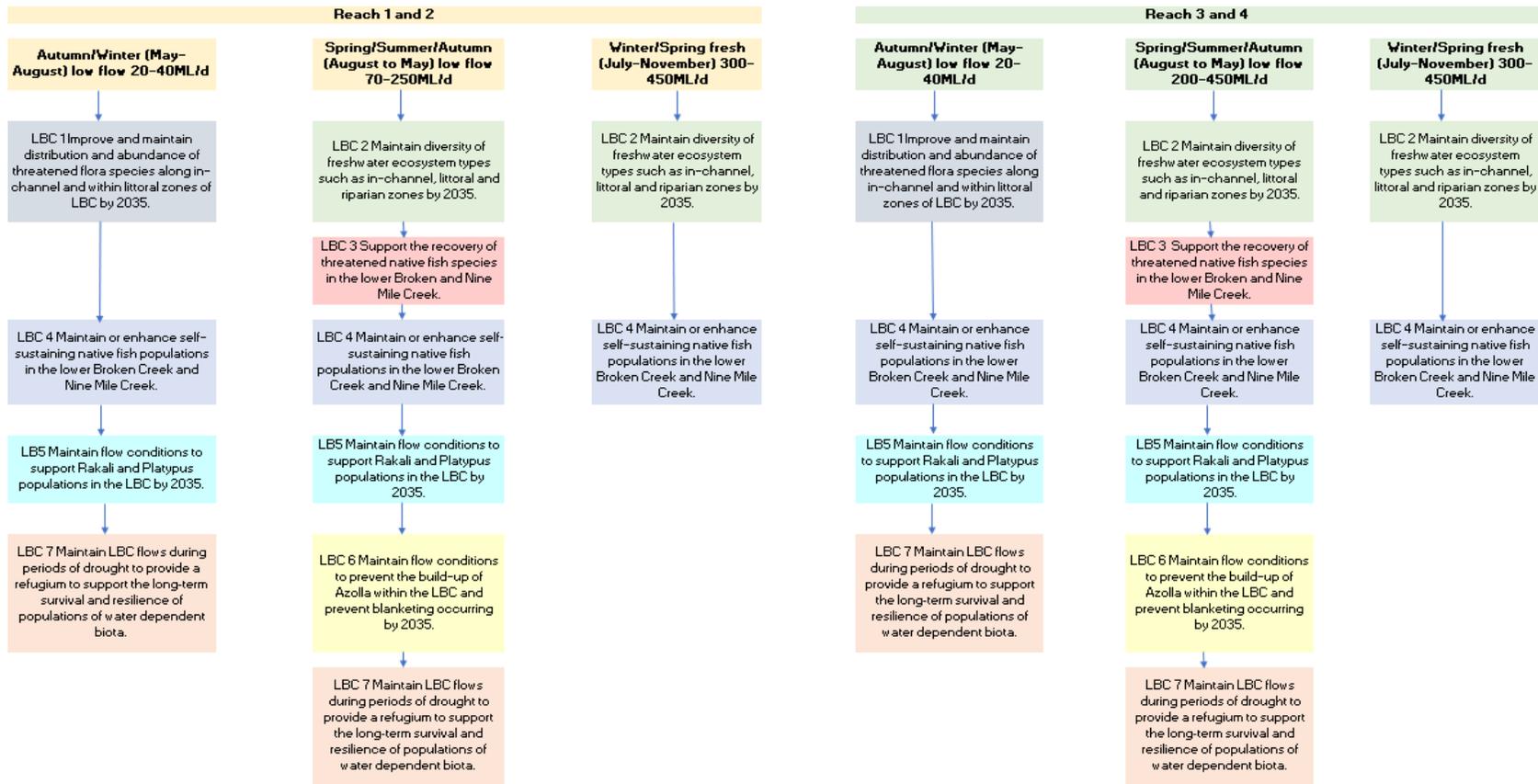


Figure 17: Lower Broken Creek and Nine Mile Creek watering decision chart

5.2.1 Regional significance

The lower Broken Creek and Nine Mile Creek is a tributary of the mid Murray system, connecting to the main Murray River channel near Barmah. It is one of many waterways that form a network of habitats available for migrating aquatic species that can travel large distances within the Murray-Darling Basin, particularly large-bodied native fish such as golden perch, Murray cod and the EPBC Act listed silver perch.

As such, environmental water delivery in the lower Broken Creek and Nine Mile Creek considers how best to contribute to system-wide opportunities for native fish distribution. In particular, the creek's discharge can be increased using environmental water during periods of fish migration to encourage a broader distribution of native species across the southern connected Basin by enabling native fish to travel into the creek from the Murray River. The creek could also be classified as a "drought refuge" during dry periods. As a novel ecosystem, it may play an important role for fish, turtles, platypus and rakali.

There is also an opportunity to provide an environmental flow in autumn each year, to enable suitable conditions and cues for native fish detected migrating up the Murray River to travel into the lower Broken Creek and Nine Mile Creek system. This was trialled in autumn 2022 and monitoring results didn't detect any species using this flow to enter lower Broken Creek and Nine Mile Creek. However, this will help inform our understanding of what role lower Broken Creek and Nine Mile Creek plays in distributing native fish across the mid-Murray region once more trials are conducted to collect a sufficient database.



5.2.2 Alignment to Basin Plan

Updated objectives now reflect improved alignment with the Basin Plan and Victorian Long-Term Watering Plans as further outlined Appendix F and described below in Table 14.

Table 14 Basin Plan Schedule 8 PEA and PEF criteria applicable to lower Broken Creek and Nine Mile Creek

Priority Environmental Asset criteria	How lower Broken Creek meets criteria
<p>Criterion 3: The water-dependent ecosystem provides vital habitat.</p> <p>A water-dependent ecosystem is an environmental asset that requires environmental watering if it: (a) provides vital habitat, including: (i) <u>a refugium for native water-dependent biota during dry spells and drought</u>; or (ii) <u>pathways for the dispersal, migration and movements of native water-dependent biota</u>; or (iii) important <u>feeding, breeding and nursery sites</u> for native water-dependent biota; (b) is essential for <u>maintaining, and preventing declines</u> of, native water-dependent biota.</p>	<p>The creek provides drought refuge habitat with secure water for flows during summer.</p> <p>Fishways allow for fish movement with all listed species detected moving through fishways as part of migratory and dispersal behaviour.</p> <p>Murray cod, Unspecked hardyhead and Murray-Darling rainbowfish breeding site – evidence of local spawning and recruitment. The lower Broken Creek and Nine Mile Creek provides habitat that supports the existing range for all other listed fish species.</p>
<p>Criterion 4: Water-dependent ecosystems that support Commonwealth, State or Territory listed threatened species or communities.</p> <p>A water-dependent ecosystem is an environmental asset that requires environmental watering if it:</p> <p>(a) supports a listed threatened ecological community or listed threatened species;</p> <p>(b) supports water-dependent ecosystems treated as threatened or endangered (however described) under State or Territory law;</p> <p>(c) supports one or more native water-dependent species treated as threatened or endangered (however described) under State or Territory law.</p>	<p>The creek supports several listed threatened native fish. Managed flows including additional environmental water are required to promote key life history processes including movement, spawning and survival.</p> <p>The lower Broken Creek and Nine Mile Creek supports listed vegetation communities and species. Environmental water is one important management action to maintain these, but other actions are also required, e.g. livestock removal, revegetation, reduce erosion.</p>
Priority Ecosystem Function criteria	How lower Broken Creek meets criteria
<p>Criterion 1: The ecosystem function supports the creation and maintenance of vital habitats and populations</p> <p>An ecosystem function requires environmental watering to sustain it if it provides vital habitat, including:</p> <p>(a) a refugium for native water-dependent biota during dry periods and drought; or</p> <p>(b) pathways for the dispersal, migration and movement of native water-dependent biota; or</p> <p>(c) a diversity of important feeding, breeding and nursery sites for native water-dependent biota; or</p> <p>(d) a diversity of aquatic environments including pools, riffle and run environments;</p> <p>(e) a vital habitat that is essential for preventing the decline of native water-dependent biota.</p>	<p>Lower Broken Creek and Nine Mile Creek provides important refuge during dry periods and allows for the movement of native fish and other native water-dependent biota.</p> <p>Sustained high flow levels will support a subset of plant species but will be damaging to others. Without flow level variation, many of these functions are inhibited. Declines in bank condition reduce ecosystem functions by restricting suitable habitat for plant germination and survival.</p>
<p>Criterion 3: The ecosystem function provides connections along a watercourse (longitudinal connections).</p> <p>Assessment indicator: An ecosystem function requires environmental watering to sustain it if it provides connections along a watercourse or to the ocean, including longitudinal connections: (a) for dispersal and re-colonisation of native water-dependent communities; or (b) for migration to fulfil requirements of life-history stages; or (c) for in-stream primary production.</p>	<p>Lower Broken Creek and Nine Mile Creek provides longitudinal connection to the Murray River for dispersal of locally spawned fish e.g. Murray cod, Unspecked hardyhead and Murray-Darling rainbowfish and provides refugia during hypoxic blackwater events in the Murray River and vice versa.</p>

5.3 CULTURAL OBJECTIVES ALIGNED WITH WATERING OBJECTIVES

As described in Section 3.2.1 the Yorta Yorta Nation Aboriginal Corporation were invited to partner in the development of this Plan and to be a member of the Project Steering Committee but were unable to actively participate in the process. The environmental objectives contained within were supported by Yorta Yorta and align with their values of caring for Country. Environmental water deliveries have been specifically targeted to support instream vegetation and native fish, along with other aquatic biota. The Goulburn Broken CMA will continue to work with Yorta Yorta Nation Aboriginal Corporation to identify how environmental water management can best support cultural values.

In previous meetings to discuss Seasonal Watering Proposals, Yorta Yorta raised concern about the cultural damage water transfers are having on the lower Goulburn River and the Barmah Narrows, this was in addition to the ecological damage being caused. Using the lower Broken and Nine Mile Creeks for delivery of water (either environmental or consumptive) to the lower Murray River as a bypass mechanism, may help reduce risk of erosion on the Barmah Narrows and lower Goulburn River and thus help to protect culturally significant values. Use of lower Broken Creek and Nine Mile Creek as an alternative pathway for such deliveries has been identified in the Yorta Yorta Whole-of-Country Plan (YYNAC 2021).

The Yorta Yorta Nation Aboriginal Corporation have identified several objectives, outcomes and actions related to water management on Yorta Yorta Country as outlined within Section 3.2.1 and Table 3.

6 ENVIRONMENTAL WATER REQUIREMENTS

6.1 WATERING REQUIREMENTS

Flow recommendations for the lower Broken and Nine Mile Creeks have been developed by Jacobs (2019) for the ecological objectives described in Section 5.2 as part of the Lower Broken Creek Flows Study which used the FLOWS method revision 2 (DEPI 2013).

The Flows study aimed to develop environmental flow recommendations for the lower Broken and Nine Mile Creeks that:

- Maximise environmental outcomes within the context of the ongoing need to provide regulated flows in summer-autumn to meet irrigation demands.
- Consider current and future environmental water availability, and the implications for environmental objectives that might be set for the lower Broken Creek and Nine Mile Creek system.
- Identify complementary actions that may enhance the benefits of environmental water delivery in this system.

It also considered the potential for high flows over the summer with delivery of water to meet downstream demands in the form of Inter-Valley Trade or for helping meet environmental demands downstream of the Barmah Narrows using Murray bypass flows. As such, the Flows study also considered the potential impacts associated with these flows and provided advice on an upper threshold of volume or timing of Inter-Valley Trade flows (Jacobs 2019).

The flow recommendations are expressed in terms of a watering requirement that specifies the timing (time of year), component / event (cease to flow, low flow, fresh, high flow, bank full or overbank flow), volume or magnitude, frequency (number of events per year or interval between events) and duration (days, months etc.). Collectively, the individual flow components comprise a regime that, if achieved, would have a high likelihood of achieving the specified environmental objectives.

Recommendations have not been considered in the context of climate conditions (dry, average, or wet) as the values identified during the environmental flows study do not have different watering requirements depending on the climatic conditions experienced. However, it is probable that delivery patterns may change according to climate condition (i.e., sustaining baseflows during long dry periods over summer).



6.2 EXPECTED WATERING EFFECTS

The expected watering effects of a potential watering action in a system relates to the physical, chemical, biological or behavioural responses to a watering regime and clarify the outcomes expected with environmental watering actions.

Table 15 provides detail on the expected watering effects that may occur along lower Broken and Nine Mile Creeks during an environmental water delivery.

Table 15: Expected watering effects at lower Broken and Nine Mile Creeks

Potential watering action	Expected watering effect
Winter low flow (20-40ML/day during May to August)	<ul style="list-style-type: none"> • Provide native fish with passage through fish ladders. • Provide suitable foraging habitat for platypus and rakali (water rats) and support the conditioning of females in preparation for the breeding season. • Provide habitat for turtles, including protection from exposure during their winter dormancy. • Provide flowing-water habitat and avoid winter drying of weir pools for fish, vegetation, aquatic insects, platypus and turtles. • Maintain water over submerged aquatic plants so they are protected from drying and frost. • Reduce the stagnation of weir pools.
Spring/summer/autumn low flow (70-250 ML/ day in reaches 1 and 2 and 200-450 ML/day in reaches 3 and 4 during August to May)	<ul style="list-style-type: none"> • Provide habitat for native fish, platypus, rakali (water rats), turtles and aquatic insects. • Support the movement and recruitment of fish. • Maintain oxygen levels in summer. • Additional benefits when delivered from December to February (at 250- 450 ML/day). • Mobilise azolla and increase oxygen levels during high-risk periods.
Winter/spring fresh(es) (one to three freshes of 300-450 ML/day for one to two weeks during July to November)	<ul style="list-style-type: none"> • Flush and mobilise azolla if it has accumulated to maintain water quality. • Trigger the movement and spawning of fish. • Encourage the germination and growth of littoral and in-stream vegetation. • Reduce the stagnation of weir pools.
Autumn Fresh (one fresh of 80-450ML/day during March to April)	A fish attractant flow was tested in autumn 2022 – results did not find any fish using this flow to travel up into the system. TBC whether to be tested again over consecutive years.

Note: flows over 300 ML/day can flush Azolla whilst it is still in single layers or individual plants. Flushes up to 450 ML/day disperse large blooms.

6.3 SEASONALLY ADAPTIVE APPROACH

A seasonally adaptive approach identifies the priorities for environmental watering under different climatic conditions. This means that watering events can be tailored to current conditions and forecasts and be easily adapted in response to short-term local climatic variability, as conditions change throughout the year.

The demand and utilisation of environmental water may vary according to changing climatic conditions. Scenarios are based on receiving catchment inflows with a Probability of Exceedance (PoE)⁷ and the likely availability of environmental water, based on data from Goulburn-Murray Water. The scenarios are extreme dry/drought (99% PoE), dry (90% PoE), average (50% PoE) and wet (10% PoE). These scenarios were chosen as they may result in different natural inflows to the waterways and the volume of environmental water required.

However, the lower Broken Creek and Nine Mile Creek system differs to many other environmental water locations in that the environmental flow needs are relatively fixed from year to year i.e. are largely independent of annual climatic conditions. This makes the standard scenario planning process less applicable. Firstly, most of the water in the lower Broken Creek and Nine Mile Creek system is sourced from the Murray and Goulburn Rivers through regulating structures. Catchment runoff may contribute short flow peaks in winter and spring but does not significantly contribute to environment flow needs apart from in very wet years.

⁷ Probability of Exceedance describes the likelihood of a specific volume being exceeded in a given time period e.g. 90% PoE means that 90 out of 100 times we would expect higher inflow volumes.

However, even in wet years the potential watering actions may not change. E.g. the timing of natural freshes may occur later in the year after managed freshes have already been delivered, or flow may be required to restore dissolved oxygen levels in the creeks after flood waters pass. Potential watering actions therefore remain consistent across each scenario, although their timing and purpose may change from year-to-year depending on the conditions. Secondly, the volume of water expected to be available to the lower Broken Creek and Nine Mile Creek generally exceeds that required to meet environmental flow requirements, even under an extreme dry scenario.

This means the potential watering actions don't need to be modified to account for a lack of available water. They are instead delivered through a combination of different water sources including environmental water, Inter-Valley Trade, Murray bypass and unregulated inflows. The lack of constraining factors and therefore consistency in potential watering actions across climate scenarios, means the ecological goal for delivering environmental water in lower Broken Creek and Nine Mile Creek has a strong focus on recovery, and where possible, enhancement (while acknowledging the limitations posed by being a regulated, working creek).

This includes improving recruitment opportunities and the health and resilience of the system, rather than just maintaining it. For this reason, the lower Broken Creek and Nine Mile Creek is also a good candidate for complimentary measures.

Despite the consistency in potential watering actions, the actual management of water through the season needs to be adaptive and flexible, with water delivery decisions adjusting as the season unfolds, particularly in response to the variable flow needs of *Azolla* and dissolved oxygen management.

7 ENVIRONMENTAL WATER DELIVERY INFRASTRUCTURE

7.1 WATER DELIVERY INFRASTRUCTURE

Environmental water can be delivered to the lower Broken Creek and Nine Mile Creek via a series of irrigation channel outfalls from either the Murray Valley or Shepparton Irrigation areas operated by Goulburn-Murray Water. The main delivery pathways are the East Goulburn Main channel outfall and the Murray Valley 7/3 channel outfall, both of which are at the upstream end of lower Broken and Nine Mile Creeks.

There are five outfall structures that connect directly to the lower Broken Creek and Nine Mile Creek from the Shepparton Irrigation Area, and six outfalls from the Murray Valley irrigation area. The approximate delivery volumes through the various outfalls are shown in Table 15 below.

As part of the historic modernisation programs, four outfalls have been decommissioned or partially decommissioned (Figure 17). The partially decommissioned outfalls are a result of the channels being shortened and the channel directly upstream of the outfall into the creeks now act as drains passing floodwater. All delivery infrastructure is owned and operated by Goulburn-Murray Water.

Table 16: Outfall delivery rates (ML/d)

Irrigation Area	Outfall	Delivery rate (ML/d)
Murray Valley	7/3 channel	60
	4 Main	10
	6/6	20
	15/6	35
	Jewells	35
	26A/6 Flanners	70
Shepparton	East Goulburn Main	250
	Hicks	40
	Hollands	20

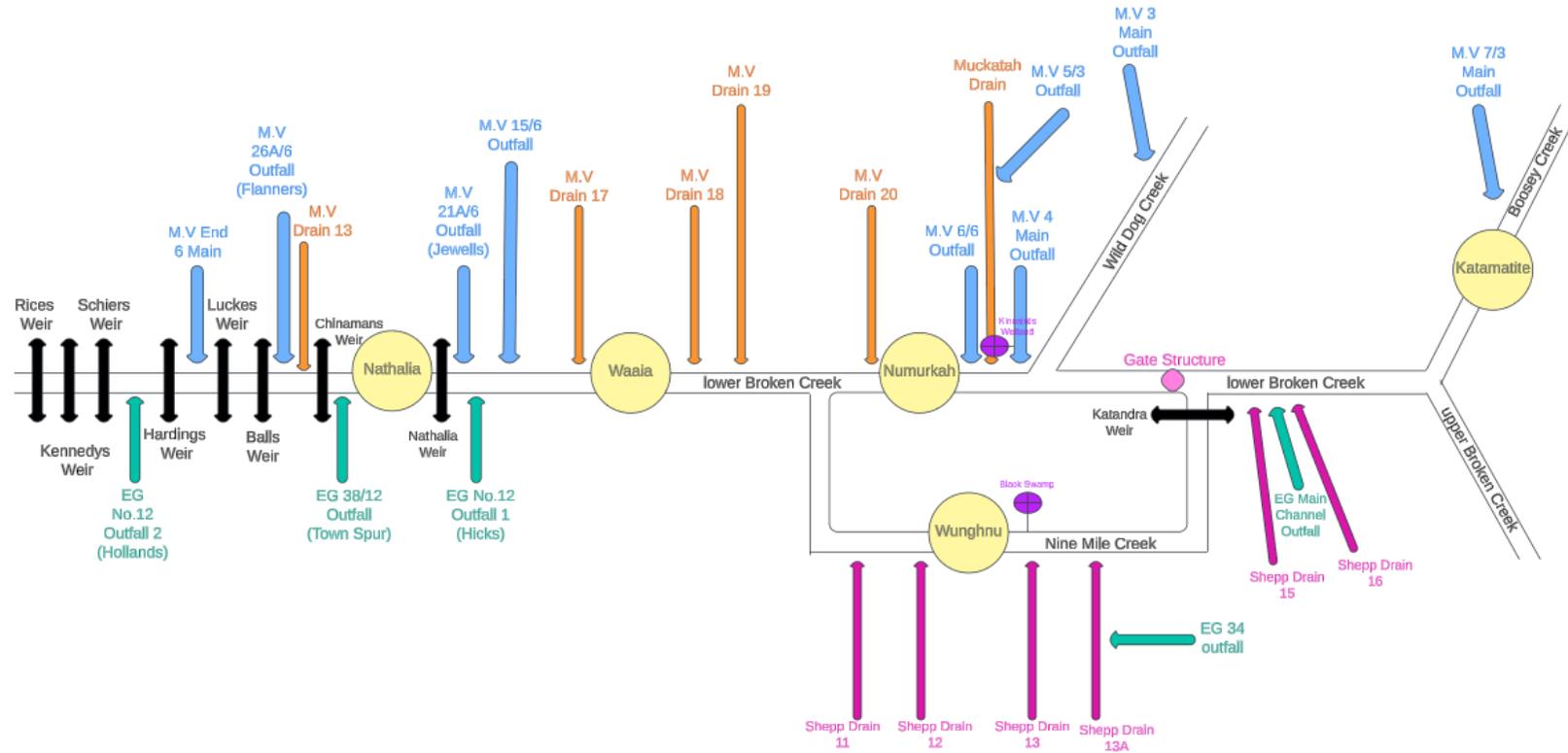


Figure 18: Schematic of lower Broken Creek and Nine Mile Creek system

7.2 COMPLEMENTARY WORKS

Several complementary works are recommended to improve the outcomes from environmental water delivery in lower Broken Creek and Nine Mile Creek. These were suggested in Jacobs Flow study (2019) and include:

- Riparian fencing to remove stock from the creek line in those areas where stock access remains.
- Reinstating large woody debris instream to improve native fish habitat.
- Instream planting of aquatic and ephemeral native species, especially those that help stabilise banks.
- Reinstating deep pools through silt removal to improve habitat diversity for large-bodied native fish.
- Translocation of threatened native fish species.
- Increasing opportunities to provide water level variability to reduce bank erosion and improve the recruitment and growth of littoral vegetation.
- Replacing / improving Kokoda Road culvert which provides a barrier to fish movement.

7.3 CONSTRAINTS

7.3.1 Delivery constraints

The delivery of environmental water via the channel network is constrained by the availability of spare channel capacity when irrigation demand is high, as the environment does not hold delivery shares and is therefore subject to interruptible supply. This is particularly a risk in autumn during peak irrigation demand. As a result, the estimated volumes to meet the environmental objectives for the lower Broken and Nine Mile Creeks may not be delivered.

Outside of the irrigation season, infrastructure maintenance by Goulburn-Murray Water over winter also limits the ability to deliver environmental water.

7.3.2 Flooding private land

Low lying land in reach one means that flows over 100 ML/day can create minor flooding of private land. Goulburn-Murray Water manage the Katandra Weir and the Broken Creek regulator at the top of this section to maintain flows below 100 ML/day by sending most flow down Nine Mile Creek (Reach 2).

Delivery of environmental water is not constrained by the risk of flooding private and public assets in other parts of the creek as the maximum volume able to be delivered (around 500 ML/day) represents a small proportion of the total capacity of the creeks downstream of the environmental water outfall locations (around 2,000ML/day) and Goulburn-Murray Water can actively manage flows to prevent out of channel flows.

7.3.3 Farm drains along Nine Mile Creek

Several farm drains exist along Nine Mile Creek to enable private land to drain to the creek under wet conditions. Currently, Goulburn-Murray Water opens these drains over winter and closes them with stopbanks when the risk of wet conditions passes. If environmental water is delivered while the drains are open, environmental water can enter the drains and be harvested by landholders under their drainage licenses. For this reason, deliveries are constrained to 150 ML/day on Nine Mile Creek when drains are open to prevent loss of environmental water. Goulburn-Murray Water have advised there is a long-term plan to install infrastructure (e.g. one-way stop valves) to eliminate this temporary constraint.

8 DEMONSTRATING OUTCOMES

Monitoring is required to demonstrate the effectiveness of the watering regime in achieving the stated long-term environmental objectives. It is also a critical component to the adaptive management of lower Broken and Nine Mile Creeks.

Two types of monitoring are recommended to assess the effectiveness of the proposed water regime on objectives and to facilitate adaptive management, these being long-term condition monitoring and intervention monitoring. Currently, the principle state-wide monitoring program is Victoria's Environmental Flow Monitoring and Assessment Program (VEFMAP), designed to assess the ecological response of aquatic and riverbank vegetation and fish to the delivery of environmental water in Victorian rivers.

Primary objectives of this program include:

- The ability for delivery partners to clearly demonstrate the ecological value of environmental water management to the community and water industry stakeholders.
- Fill knowledge gaps to improve planning, delivery and evaluation of environmental water management in rivers across Victoria.
- Identify ecosystem outcomes from environmental water to help meet Victoria's obligations under the Murray-Darling Basin Plan Schedule 12, Matter 8 report (DELWP 2020).

Victorian Inter-Valley Trade assessment project

2021-22 was the first year of data collection for the lower Broken Creek and Nine Mile Creek system as part of the Goulburn to Murray Trade Rule Review monitoring program, which included water level for geomorphological impacts, vegetation, and fish population surveys. The monitoring program is focussed on ensuring the operating rules are performing as intended, i.e. that the system operates within ecological tolerances to avoid damage from high, unseasonal summer flows to provide some opportunity for environmental recovery including:

- Improve the diversity of physical form including hydraulic and sediment conditions.
- Maintain a balanced level of erosion and deposition within the channel, specifically reducing the rate and extent of riverbank erosion.
- Reduce the sedimentation of pools.
- Reduce sediment deposition on the sills entering meander cutoffs/billabongs.

Other monitoring includes incidental observations and monitoring by Goulburn-Murray Water staff such as water quality monitoring. Goulburn Broken CMA staff undertake water quality monitoring in response to incidents such as flooding and photopoint monitoring is conducted along the creek to track long term trends in condition.

A more robust monitoring program that aligns with the environmental objectives and targets is suggested in Table 16 below.

Table 17: Possible monitoring program for the lower Broken Creek and Nine Mile Creek

Objective	Target	Target Monitoring & Baseline Status	Demonstrating Outcomes
LBC 1 Maintain or improve distribution and abundance of threatened vegetation species along in-channel and within littoral zones of lower Broken Creek and Nine Mile Creek by 2035.	Maintain or increase populations of listed aquatic vegetation species such as Slender Water Ribbons and Rigid Water Milfoil in the lower Broken Creek and Nine Mile Creek at 2022 level.	Existing monitoring program annually via the Goulburn to Murray Trade Review Project – currently program is committed to 2026 Baseline data for abundance of priority vegetation in the ‘Aquatic Zone’ across 10 survey sites – established 2022. Surveys to be conducted across the next 10 years.	Collated vegetation survey data over the extended period. Delivering hydrographs to meet vegetation objectives – reported annually
LBC 2 Maintain diversity of freshwater ecosystem types such as in-channel, littoral and riparian zones by 2035.	Aquatic vegetation species diversity and abundance in lower Broken Creek and Nine Mile Creek is improved or maintained at 2022 levels.	Existing monitoring program annually via the Goulburn to Murray Trade Review Project – currently program is committed to 2026 Baseline data for abundance of priority vegetation in the ‘Aquatic Zone’ across 10 survey sites – established 2022. Surveys to be conducted across the next 10 years.	Collated vegetation survey data over the extended period. Delivering hydrographs to meet vegetation objectives – reported annually
LBC 3 Support the recovery of threatened native fish species in the lower Broken and Nine Mile Creek.	By 2035, the re-introduction of two threatened native fish species within the lower Broken Creek and Nine Mile Creek systems. Measured as re-introduction of two species (eg. Freshwater Catfish, Southern Pygmy Perch, Flat-headed Galaxias), and species detections in subsequent surveys.	Existing monitoring program annually via the Goulburn to Murray Trade Review Project – currently program is committed to 2026 Historic threatened Species detected include: Murray Cod (EPBC & FFG) – 1 captured in 2024 Trout Cod (EPBC & FFG) – 0 captured in 2024 Silver Perch (EPBC & FFG) – 0 captured in 2024 Murray-Darling Rainbowfish (FFG) – 3 captured in 2024 Target met in 2024.	Collated fish survey data over the extended period. Delivering hydrographs to meet fish objectives – reported annually

		<i>*Note FFG listed Freshwater catfish have been translocated to the LBC, however unlikely to be captured in future surveys</i>	
LBC 4 Maintain or enhance self-sustaining native fish populations in the lower Broken Creek and Nine Mile Creek.	By 2035, the trajectory (catch per unit effort, species distribution, population structure) of key target species (Murray Cod, Murray-Darling rainbowfish and Australian Smelt) will be at or above 2024 levels.	Existing monitoring program annually via the Goulburn to Murray Trade Review Project – currently program is committed to 2026 Management of the system by GB CMA will monitor fish kill events 2008-2023 survey result averages Murray Cod – 54 (2035 target captured 70) Aus Smelt – 84 (2035 target captured 110) Murray-Darling Rainbowfish – 34 (2035 target captured 44)	Collated fish survey data over the extended period. Delivering hydrographs to meet fish objectives – reported annually
LBC 5 Maintain flow conditions to support Rakali and turtle populations and recruitment of platypus in the lower Broken Creek and Nine Mile Creek by 2035.	To encourage the movement of Platypus, Rakali and turtles in the lower Broken Creek and Nine Mile Creek system by 2035. Aiming for flows during Platypus breeding season (August-September) have minimum impact on burrows.	No existing formal monitoring program (for the species) Incidental observations noted Environmental water baseflow targets are monitored	Annual hydrographs demonstrating proportion of time meeting e-water flow objectives for platypus, rakali and turtles– to be reported in system seasonal summary
LBC 6 Maintain flow conditions to prevent the build-up of Azolla within the lower Broken Creek and Nine Mile Creek and prevent blanketing occurring by 2035.	Mitigate the impact of Azolla blooms occurring by 2035.	Management of the system by Goulburn Broken CMA will monitor and respond to Azolla bloom events	Azolla bloom events– to be reported in system seasonal summary.
LBC 7 Maintain lower Broken Creek and Nine Mile Creek flows during periods of drought to provide a refugium to support the long-term survival and resilience of populations of water dependent biota.	Maintain flows > 200ML/d at Rices Weir during drought to provide refugium for water dependent species.	Flow delivery data plus climatic conditions (i.e. Drought) will be available.	Annual hydrographs available, will be overlaid with declared drought periods. Watering proposals and deliveries will prioritise adequate baseflows during drought.

9 KNOWLEDGE GAPS

There are currently several knowledge gaps in relation to environmental water management within lower Broken Creek and Nine Mile Creek. While most of these do not impact the ability to provide water to the system and generate ecological benefit, addressing these would provide long-term ecological understanding of the site.

The Yorta Yorta Nation Aboriginal Corporation was invited to partner in development of the Plan and to be a member of the Project Steering Committee but were unable to actively participate in the process. This has led to a gap in knowledge regarding cultural objectives as they may align with the environmental objectives stated here in this Plan.

The key knowledge gaps related to each environmental objective are outlined below in Table 16.

Table 18: Knowledge gaps for the lower Broken and Nine Mile Creeks

Environmental Value	Long-term environmental objective	Knowledge gap	Implications and planned monitoring
Fish	<p>Maintain or increase the distribution of each native fish species.</p> <p>Improve the relative abundance of native fish in each reach.</p> <p>Reduce fish deaths from poor water quality.</p> <p>Maintain native fish habitat and passage all year, particularly during migration and breeding seasons.</p>	<p>Evidence of migration, spawning events and recruitment following specific flows.</p> <p>How weir pool manipulation (water level rise) in conjunction with fresh delivery could optimise flow cues for native fish.</p> <p>How carp respond to different flow components.</p> <p>How head loss through Rices Weir could be increased at times of high juvenile carp immigration to prevent access to the creek.</p> <p>Fish movement patterns in the absence of winter low flow i.e. refuge locations.</p>	<p>Regular fish surveys are required to enable adaptive management of watering actions and identify whether progress is being made towards the long-term environmental objective.</p> <p>Fish surveys have been conducted in 2008, 2010, 2016, 2021, 2022, 2023, 2024.</p> <p>Other research opportunities are subject to funding.</p>
Other native aquatic fauna	<p>Provide permanent aquatic habitat in all reaches year round, including during drought, for aquatic biota.</p>	<p>Status of platypus, Rakali and turtles – abundance and distribution.</p>	<p>In the absence of surveys, it is unknown whether populations are stable and whether over-wintering habitat provided through current winter low flows is adequate for these species.</p> <p>No surveys are scheduled in the near future.</p>
Other native aquatic fauna	<p>Provide permanent aquatic habitat in all reaches year round, including during drought, for aquatic biota.</p>	<p>If and how the diversity and abundance of macroinvertebrates is changing, especially given recent hypoxic events.</p> <p>How the macroinvertebrate community is recovering from hypoxic events.</p>	<p>In the absence of surveys, it is unknown whether the macroinvertebrate community is being maintained.</p> <p>Given this is a key food resource for fish, turtles and platypus, it is also unknown whether the macroinvertebrate community is limiting the ecological health of the system.</p> <p>The last survey was completed in 2015-16. No surveys are planned in the near future.</p>
Vegetation	<p>Reduce proliferation of <i>Azolla</i> in the weir pools downstream of Nathalia.</p>	<p>None identified.</p>	<p>Regular monitoring of <i>Azolla</i> levels (particularly in reach 4) will continue (Goulburn Broken CMA, GMW).</p>

Environmental Value	Long-term environmental objective	Knowledge gap	Implications and planned monitoring
Vegetation	<p>Improve beds of submerged and emergent macrophytes (e.g. <i>Vallisneria australis</i>, <i>Ludwigia</i> sp. and <i>Myriophyllum</i> sp.).</p> <p>Improve the development of a diverse and extensive littoral vegetation community along the creek and in meander cutoffs/billabongs.</p>	<p>If and how the cover and condition of native instream and littoral vegetation is changing and where the seedbank is coming from.</p> <p>What flows provide optimum conditions for native vegetation, particularly in the littoral zone.</p> <p>Whether consistent high flows associated with water-in-transit deliveries are impacting littoral vegetation.</p>	<p>Regular vegetation monitoring is needed to determine progress against the long-term objective and enable adaptive management of watering actions, particularly any risks associated with consistently higher flows.</p> <p>An autumn bank vegetation survey was conducted in 2022 and follow-up autumn surveys are planned under the Goulburn to Murray Trade Rule Monitoring Program.</p>
Water Quality	<p>Maintain adequate dissolved oxygen for aquatic biota in all reaches year round (including during heat waves and hypoxic blackwater events).</p> <p>Reduce turbidity by reducing bank erosion.</p> <p>Improve carbon and nutrient cycling by providing greater water level variability.</p> <p>Improve energetic functional pathways including the number and length</p> <p>Reduce development of BGA blooms.</p> <p>Improve biofilms.</p>	<p>Why Rices Weir pool is prone to lower DO levels compared to other weir pools in reach 4.</p>	<p>Regular monitoring of dissolved oxygen levels (particularly in reach 4) will continue (Goulburn Broken CMA, GMW).</p> <p>Establish bank erosion monitoring sites along the Upper Broken creek.</p>
Geomorphology / Physical form	<p>Improve the diversity of physical form and hydraulic conditions.</p> <p>Improve the movement of sediment through the system to facilitate feature formation and reduce negative impacts such as bed smothering.</p> <p>Maintain a balanced level of erosion and deposition within the channel, specifically reducing the rate and extent of riverbank erosion.</p> <p>Reduce sediment deposition on the sills</p>	<p>How to recreate the diversity of physical features including in-channel benches, bars and pools to increase depth diversity and hydraulic variability, with interrupted sediment supply and limited connectivity.</p> <p>An understanding of sediment movement through the system is limited.</p> <p>Erosion of riverbanks, including notching and mass failure, has been linked to a lack of flow variability (particularly in reach 4). The ability to manipulate is a limitation in knowledge and opportunities.</p> <p>Knowledge of connectivity and sill levels of billabong/cutoffs could be improved.</p>	<p>A water level and bank condition investigation was completed by Streamology (2023). It found the primary erosional process on lower Broken Creek and Nine Mile Creek is notching of banks due to prolonged static water levels.</p> <p>Incorporate into monitoring an understanding of sediment transport and deposition.</p> <p>The primary means of maintaining (or improving) bank condition on lower Broken Creek and Nine Mile Creek is to avoid static water levels and introduce more variability in water levels to mimic a more natural regime. This is a challenge due to the dominant influence of weirs (specifically in reach 4) whereby flow variability does not translate to water level variability.</p>

Environmental Value	Long-term environmental objective	Knowledge gap	Implications and planned monitoring
	entering mender cutoffs/ billabongs.		

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11 APPENDICES

11.1 APPENDIX A: FINDINGS FROM THE LOWER BROKEN CREEK AND NINE MILE CREEK PLANS COMMUNITY CONSULTATION PROCESS

What do you value most about the creek?

- The aesthetics – scenery and beauty x 2
- Corridor of habitat along the Broken Creek and Nine Mile Creek – reserve system.
- Good water quality x 2
- The creek is a better colour now.
- Water available year-round.
- Fish community and fishing.
- Bird life.

What would you like to see improved?

- Water level management
 - 2021-22 was a higher water level resulting in more under-mining of the creek banks and trees falling in.
 - 2022-23 the creek was running lower so there was less erosion (outside of flood times).
- A regular inflow (e.g. outfall from channel 12) seems to help fish and yabbies etc, particularly when the water quality is bad.
- The lack of flow during winter x 2. It affects tourism and fishing. It's also not good for foot valves. Don't want the weir pools in town (Nathalia) to empty out.
- Blue-green algae is more prevalent now.
- More flow being put in from the Murray and Goulburn – these have better quality water (better colour).
- Addressing the silt build up. x 2 Weirs don't help deep pools. A lot of deep pools have filled in.
- Reduce carp numbers.
- Maintain a high level of water between the two town weirs for water activities, fishing, canoeing.
- Stop grazing to the edge of the creek.
- Woody weeds (desert ash) are starting to become more common (e.g. around Nathalia town bridge). These need to be removed.
- There are too many suckers along Weir Street (between the bridge and Chinamens Weir) – it's impacting the ability to fish during fishing competitions.
- The fish community – fish abundance was better 12 years ago. Used to catch 30-40 fish in a 5-hr fishing competition, now only get 8-10. We're not getting golden perch migration into the creek and stocking isn't the answer. We've been stocking heaps and aren't seeing the fish numbers respond.
- Fishway maintenance – snags get caught on them and block them. Need more regular clean outs and checking to make sure they're working. Re-align snags where appropriate.

What do you think are the highest priorities to focus on?

- Water quality management x 2. E.g. reduce blue-green algae, sediment and nutrients.
- Adequate flow – good management of flows including having winter flows.
- Weed control when needed (some willows are beginning to re-appear). Want no willow trees x 2.
- Keep on top of weed control – it's good at the moment (e.g. arrowhead) x 2.
- Keep main channel (i.e. creek weirs) open – floods are super expensive.
- Reduce carp.
- Riparian fencing – off-channel watering.
- Stopping the creek from widening and shallowing – used to be narrow and deep.
- Suggest having focus areas around the towns (fishing and recreational areas) e.g. 3km stretch. Focus lots of management in set spots to see if it makes a difference and then roll it out elsewhere.
- Silt management – improving the depth.
- Improved fish – increase instream structural habitat for fish but don't need extra snags and habitat pools near towns – pretty good currently around Nathalia. Focus on areas that are poor.
- Recognition of the importance of the creek environment.
- Improve the diversity of the riparian zone.
- Make sure there are people in control of the weirs to open them early enough in a flood situation.

What does a perfect lower Broken Creek and Nine Mile Creek environment look like?

- Reduced carp numbers leading to cleaner water and less erosion of the banks.
- Good stocks of edible native fish.
- Clearer water.
- Don't know.

Other comments

- The age of attendees is disappointing – absence of young to middle-aged community members.
- Historically (when I was a kid) the creek was clearer, had lots of large freshwater mussels and we used to go swimming in the deep holes. The Nathalia pool used to be in the creek – there were jetties and a diving board.

11.2 APPENDIX B: ECOLOGICAL VEGETATION CLASSES OF THE LOWER BROKEN AND NINE MILE CREEKS

A hierarchical system of classification of vegetation communities has been developed in Victoria over the past decade to classify vegetation into units that are both ecologically meaningful and useful for vegetation managers. The classification that has been adopted in Victoria is Ecological Vegetation Classes (EVCs), which are defined by a combination of floristics, lifeform, position in the landscape and an inferred fidelity to environments. Each EVC includes a collection of floristic communities, which occur across a biogeographic range, and although differing in species, have similar habitat and ecological processes operating. Approximately 300 EVCs have been described for Victoria. The combination of EVC and bioregion (BioEVC) is used to determine the bioregional conservation status (BCS) of an EVC. This is a measure of the current extent and quality for each EVC, when compared to its original (pre-1750) extent and condition. On this basis, a BioEVC will have a BCS of endangered, vulnerable, depleted, least concern or rare (DELWP 2022).

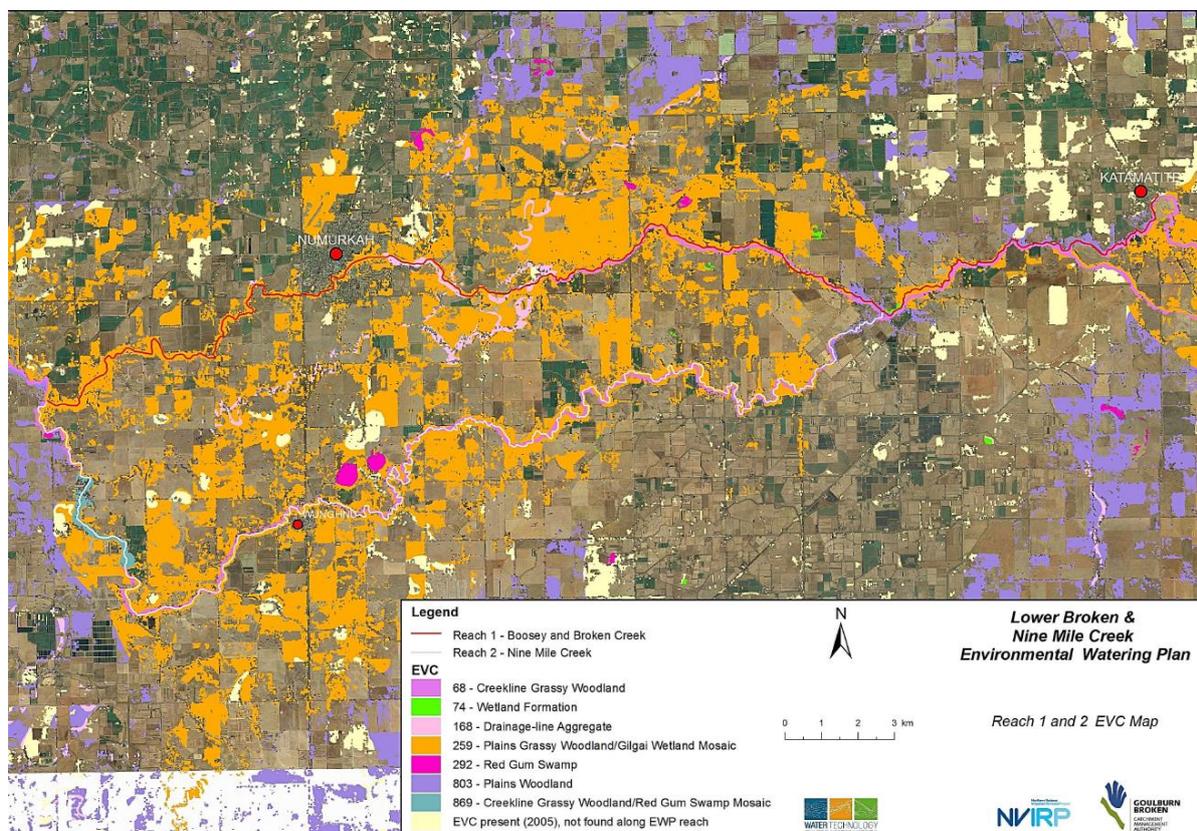


Figure 19: Reach 1 and Reach 2 Ecological Vegetation Classes

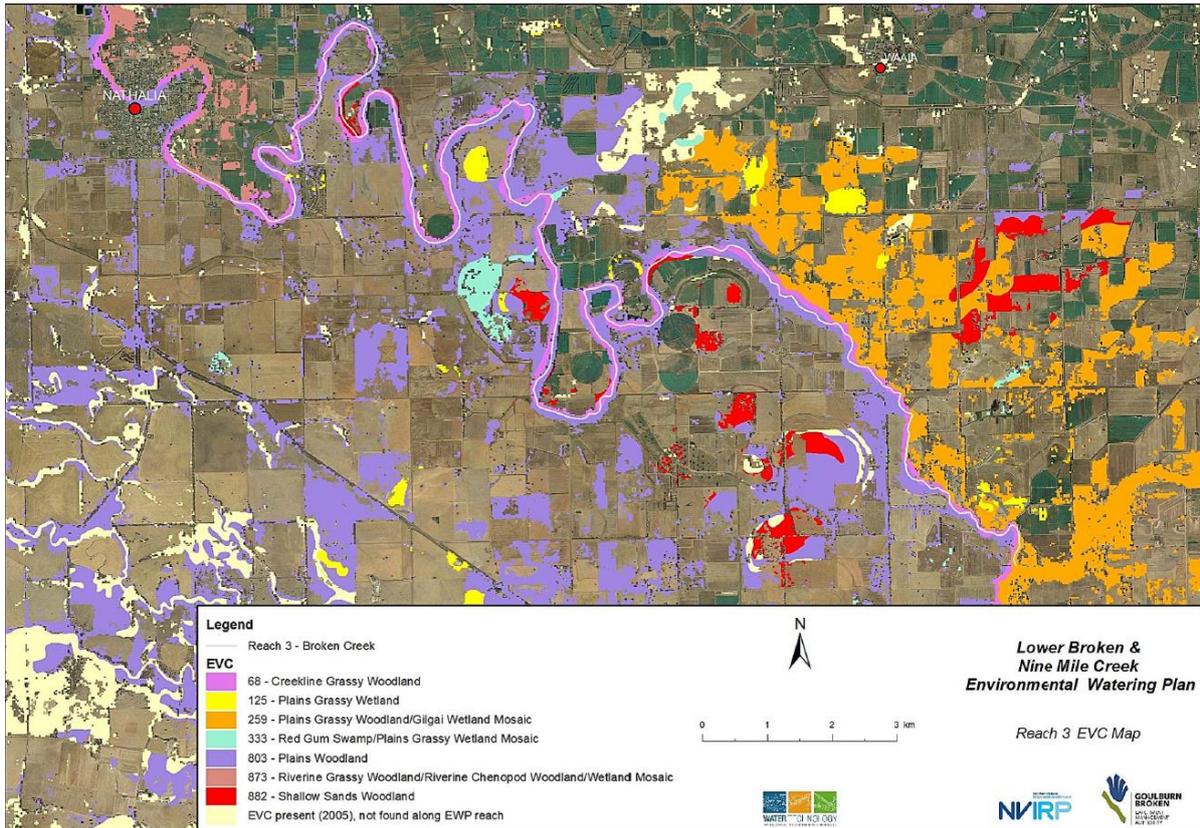


Figure 20: Reach 3 Ecological Vegetation Classes

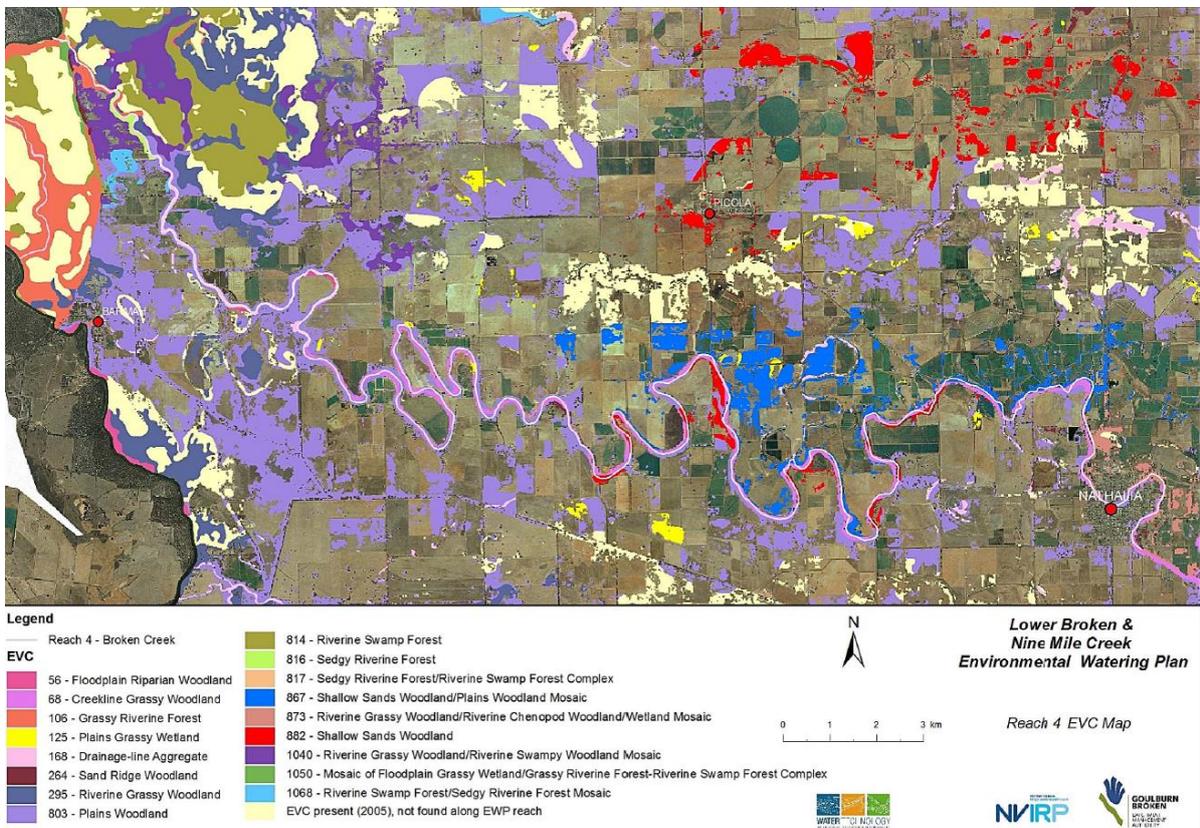


Figure 21: Reach 4 Ecological Vegetation Classes

11.3 APPENDIX C: LISTED FLORA OF LOWER BROKEN CREEK AND NINE MILE CREEK

Table 19: Flora of the lower Broken Creek and Nine Mile Creek

Scientific name	Common name	EPBC status	FFG status	Reach	Indigenous use
<i>Acacia loderi</i>	Nealie		v	Reach 3 and 4	
<i>Acacia notabilis</i>	Mallee Golden Wattle		v	Reach 3 and 4	
<i>Acacia omalophylla</i>	Yarran Wattle		e	Reach 3 and 4	
<i>Acacia oswaldii</i>	Umbrella Wattle		v	Reach 3 and 4	
<i>Acacia pendula</i>	Weeping Myall		e	Reach 3 and 4	
<i>Allocasuarina luehmannii</i>	Buloke			Reach 1, 2, 3	
<i>Alternanthera nodiflora</i>	Common Joyweed		k	Reach 1, 2, 3	
<i>Amphibromus fluitans</i>	River Swamp Wallaby-grass	V	k	Reach 3 and 4	
<i>Amyema linophylla</i> ssp. <i>Orientalis</i>	Buloke Mistletoe		v	Reach 3 and 4	
<i>Atriplex spinibractea</i>	Spiny-fruit Saltbush		e	Reach 1, 2, 3	
<i>Brachyscome chrysoglossa</i>	Yellow-tongue Daisy		v	Reach 1, 2, 3 and 4	
<i>Brachyscome muelleroides</i>	Mueller Daisy	V	e	Reach 1, 2, 3 and 4	
<i>Callitriche cyclocarpa</i>	Western Water-starwort	V	v	Reach 3 and 4	
<i>Callitriche umbonata</i>	Winged Water-starwort		r	Reach 1, 2, 3	
<i>Calotis cuneifolia</i>	Blue Burr-daisy		r	Reach 1, 2, 3	
<i>Calotis lappulacea</i>	Yellow Burr-daisy		r	Reach 1, 2, 3	
<i>Cardamine moirensis</i>	Riverina Bitter-cress		r	Reach 1, 2, 3	Leaves are eaten and used for gut health.
<i>Cardamine paucijuga</i> s.s.	Annual Bitter-cress		v	Reach 1, 2, 3	
<i>Cullen parvum</i>	Small Scurf-pea	E	e	Reach 3 and 4	
<i>Cullen tenax</i>	Tough Scurf-pea		e	Reach 3 and 4	
<i>Cyperus bifax</i>	Downs Nutgrass		v	Reach 3 and 4	
<i>Digitaria ammophila</i>	Silky Umbrella-grass		v	Reach 3 and 4	
<i>Eleocharis pallens</i>	Pale Spike-sedge		k	Reach 1, 2, 3	
<i>Eryngium paludosum</i>	Long Eryngium		v	Reach 1, 2, 3 and 4	
<i>Glossostigma cleistanthum</i>	Small-flower Mud-mat		r	Reach 1, 2, 3	
<i>Hakea tephrosperma</i>	Hooked Needlewood		v	Reach 3 and 4	
<i>Haloragis glauca</i> f. <i>glauca</i>	Bluish Raspwort		k	Reach 1, 2, 3	
<i>Hypoxis exilis</i>	Swamp Star		v	Reach 1, 2, 3	
<i>Isolepis congrua</i>	Slender Club-sedge		v	Reach 3 and 4	
<i>Leiocarpa leptolepis</i>	Pale Plover-daisy		e	Reach 1, 2, 3	
<i>Lepidium pseudohyssopifolium</i>	Native Peppergrass		k	Reach 1, 2, 3	
<i>Lipocarpa microcephala</i>	Button Rush		v	Reach 3 and 4	
<i>Maireana aphylla</i>	Leafless Bluebush		v (B) k (C)	Reach 1, 2, 3 and 4	
<i>Menkea crassa</i>	Fat Spectacles		e	Reach 3 and 4	
<i>Minuria integerrima</i>	Smooth Minuria		r	Reach 1, 2, 3	
<i>Myoporum montanum</i>	Waterbush		r	Reach 1, 2, 3	

<i>Myriophyllum gracile</i> var. <i>lineare</i>	Slender Water-milfoil		e		Reach 1, 2, 3 and 4
<i>Myriophyllum porcatum</i>	Ridged Water-milfoil	V	v		Reach 1, 2, 3 and 4
<i>Myriophyllum striatum</i>	Striped Water-milfoil		v		Reach 1, 2, 3
<i>Panicum laevinode</i>	Pepper Grass		v		Reach 1, 2, 3
<i>Panicum queenlandicum</i> var. <i>queenlandicum</i>	Coolibah Grass		e		Reach 1, 2, 3
<i>Ranunculus papulentus</i>	Large River Buttercup		k		Reach 3 and 4
<i>Ranunculus sessiliflorus</i> var. <i>pilulifer</i>	Annual Buttercup		k		Reach 1, 2, 3
<i>Rhodanthe stricta</i>	Slender Sunray		e		Reach 3 and 4
<i>Sclerolaena muricata</i> var. <i>muricata</i>	Black Roly-poly		k		Reach 1, 2, 3
<i>Sida intricata</i>	Twiggy Sida		v		Reach 3 and 4
<i>Swainsona adenophylla</i>	Violet Swainson-pea		e		Reach 3 and 4
<i>Swainsona behriana</i>	Southern Swainson-pea		r		Reach 1, 2, 3
<i>Swainsona murrayana</i>	Slender Darling-pea	V	e		Reach 3 and 4
<i>Swainsona recta</i>	Mountain Swainson-pea	E	e		Reach 3 and 4
<i>Swainsona sericea</i>	Silky Swainson-pea		v		Reach 1, 2, 3 and 4
<i>Triglochin dubia</i>	Slender Water-ribbons		r		Reach 1, 2, 3
<i>Tripogon loliiformis</i>	Rye Beetle-grass		r		Reach 1, 2, 3

Water Plant Functional Groups

In 1997 Brock & Casanova developed a way to classify wetland plant species into water plant functional groups (WPFG) based on plant's response to the presence of water. This is possible because the plants responded differently to water depths, durations and frequency of flooding. Therefore, by defining a water plant functional group to each species, sites with different suites of species, levels of biodiversity and overall water regimes can be compared. By classifying vegetation into WPFG the variability observed between groups is reduced and the ability to detect broad trends across different geographic locations is increased. Therefore, using a suite of species, grouped in relation to their responses to water, is likely to be more useful in revealing trends in water regime.

Because defining species into Water Plant Functional Groups allows a more accurate assessment of ecological condition based on water regime rather than species presence or absences, requirements for environmental flows can be determined and decisions made that will improve vegetation health across the catchment. Table 18 is taken from Casanova 2011 (WT 2016) and provides a description of the characteristics of plants in each of the water plant functional groups (WPFG). These definitions are based on WPFGs developed by Brock & Casanova (1997) with some additional groups (Brock and Casanova 1997).

Table 20: Water Plant Functional Group (WPF) definitions

Functional group code	Functional group name	Definition
Tdr	Terrestrial dry	This species group does not require flooding and will persist in damper parts of the landscape because of localised high rainfall. Species in this group can invade or persist in riparian zones and the edges of wetlands, but are essentially terrestrial
Tda	Terrestrial damp	These species germinate and establish on saturated or damp ground, but cannot tolerate flooding in the vegetative state. As such, they can persist throughout the environment in dry puddles and drains. They grow on bare ground following flooding or in places where floodwater has spread out over the landscape long enough to saturate the soil profile. They require the soil profile to remain damp for c. 3 months
ATI	Amphibious fluctuation tolerator – low-growing	This species group can germinate either on saturated soil or under water and grow totally submerged, as long as they are exposed to air by the time they start to flower and set seed. They require shallow flooding for c. 3 months
ATe	Amphibious fluctuation tolerator – emergent	This species group consists of emergent monocots and dicots that survive in saturated soil or shallow water but require most of their photosynthetic parts to remain above the water (emergent). They tolerate fluctuations in the depth of water, as well as water presence. They need water to be present for c. 8–10 months of the year, and the dry time to be in the cooler times of the year
ATw	Amphibious fluctuation tolerator – woody	This species group consists of woody perennial species that hold their seeds on their branches and require water to be present in the root zone all year round, but will germinate in shallow water or on a drying profile. If they grow on floodplains, they require flooding and restoration of the groundwater levels on a regular basis
ARp	Amphibious fluctuation responder – plastic	This species group occupies a similar zone to the ATI group, except that they have a morphological response to water level changes such as rapid shoot elongation or a change in leaf type. They can persist on damp and drying ground because of their morphological flexibility but can flower even if the site does not dry out. They occupy a slightly deeper /wet-for-longer site than the ATI group
ARf	Amphibious fluctuation responder – floating	This group consists of species that grow underwater or float on the surface of the water or have floating leaves. They require the year-round presence of free water. Many of these can survive and complete their life cycle stranded on the mud, but they reach maximum biomass growing in 'open' water all year round
Se	Perennial – emergent	This category refers to woody and monocotyledonous species that require permanent water in the root zone, but remain emergent. They thrive where water levels do not fluctuate or fluctuate little (i.e. weir pools, dams)
Sk	Submerged – k-selected	These species require a site be flooded to >10 cm for at least 6 months for them to either germinate or reach sufficient biomass to start reproducing sexually. Many have asexual reproduction (fragmentation, rhizomes and turions). Completely water-dependent, true aquatic species
Sr	Submerged – r-selected	These species colonise recently flooded areas. Many require drying to stimulate high germination percentages, and they frequently complete their life cycle quickly and die off naturally. They persist via a dormant, long-lived bank of seeds or spores in the soil. Their habitats can be flooded from once a year to once a decade, to a depth >10 cm

11.4 APPENDIX D: LISTED FAUNA OF LOWER BROKEN CREEK AND NINE MILE CREEK

Significant water-dependant fauna

The fauna of the lower Broken and Nine Mile creeks represents a variety of species suited to a diverse and complex array of habitats. Of the fauna species potentially located within or nearby the creek system, 20 water-dependant species are found to be of significance regarding their conservation including two frogs, 12 waterbirds and six fish. The connectivity of the riparian and aquatic habitat from the upper reaches within the Broken-Boosey State Park through to the Barmah-Forest ensures species dispersal supporting the high conservation significance and biodiversity of the system.

Table 21: Listed water-dependant fauna of the lower Broken and Nine Mile Creek

Scientific name	Common Name	EPBC Status	FFG Status	International Agreements
Frogs				
<i>Limnodynastes interioris</i>	Giant Bullfrog		e	
<i>Litoria raniformis</i>	Growling Grass Frog	Vu	v	
Birds				
<i>Ardea alba modesta</i>	Eastern Great Egret		v	J,C,R, Bonn
<i>Ardea intermedia plumerifa</i>	Plumed Egret		ce	
<i>Aythya australis</i>	Hardhead		v	
<i>Biziura lobata</i>	Musk Duck		v	
<i>Botaurus poiciloptilus</i>	Australasian Bittern	En	e	
<i>Egretta garzetta</i>	Little Egret		e	
<i>Antigone rubicunda</i>	Brolga		e	
<i>Ixobrychus dubius</i>	Australian Little Bittern		e	
<i>Oxyura australis</i>	Blue-billed Duck		v	
<i>Lewinia pectoralis</i>	Lewin's Rail		v	
<i>Rostratula australis</i>	Australian Painted Snipe		ce	C
<i>Stictonetta naevosa</i>	Freckled Duck		e	
Fish				
<i>Bidyanus bidyanus</i>	Silver Perch	CE	e	
<i>Gadopsis marmoratus</i>	River Blackfish		ce	
<i>Maccullochella macquariensis</i>	Trout Cod	En	ce	
<i>Maccullochella peelii</i>	Murray Cod	Vu	e	
<i>Macquaria australasica</i>	Macquarie Perch	En	e	
<i>Melanotaenia fluviatilis</i>	Murray-Darling rainbowfish		e	
<i>Tandanus tandanus</i>	Freshwater Catfish		e	

- EPBC Act listing – CE – Critically Endangered, En – Endangered, Vu-Vulnerable
- FFG Act listing (June 2023) – ex- extinct; ce – critically endangered; e – endangered; v – vulnerable; cd- conservation dependent; Threatened

Other water-dependant native fauna

Many other native water-dependent biota may utilise the lower Broken and Nine Mile Creek, including platypus, rakali, frogs and turtles as outlined below.

Platypus

Platypus have been recorded on occasion since 2003 with the most recent records from 2019 and 2020. The weir pools hold water all-year even in periods of no flow and hence may be providing important refuge habitat, especially during the non-irrigation season (Jacobs 2019). Based on limited data obtained and the incidental capture of a single female platypus during a 2010 fish survey, it is estimated that the population may currently comprise one or more breeding age females that sometimes reproduce successfully. However, the population's status and trajectory have never been assessed through targeted surveys in any part of the system.

Limiting factors potentially influencing the distribution, abundance and resilience of platypus in the system includes changes to the hydrological regime in parallel with several processes that could reduce habitat suitability (notably channel dredging and re-alignment, removal of in-stream woody habitat, increased bank and bed erosion, and increased sediment deposition in pools) (Jacobs 2019). Surface water availability in late autumn and winter appears too low to support platypus usage in many parts of the system, particularly upstream of the Nathalia town weir pool, including the Katandra Weir pool. The low-lying nature of the banks in various areas increases the likelihood that high flows occurring in late spring or summer could inundate nesting burrows, causing young to drown, significantly constraining the reproductive success over time.

Rakali (Water rats)

Rakali are found along both lower Broken and Nine Mile Creeks, though no detailed observations and studies have confirmed the species density and abundance. It has been observed that rakali, similarly to the platypus, commonly consume macroinvertebrates, and have broadly similar requirements with respect to the timing of lactation and juvenile dispersal and are vulnerable to the same range of predators. Flow requirements are also predicted to align closely with those for fish (as an important food resource), geomorphological processes that contribute to varied channel habitat features (particularly pools and backwaters), and fringing and riparian vegetation (to provide protective cover from predators and generate in-stream woody habitat, including logs and large branches serving as feeding platforms) (Jacobs 2019).

Turtles

Three species of turtle are potentially present in Broken Creek including the Eastern Snake-necked Turtle (*Chelodina longicollis*), Short Neck Turtle (*Emydura macquarii*) and Broad Shelled Turtle (*Chelodina expansa*). Recent records indicate the presence of Eastern Long-Necked and Short Necked Turtles in the catchment area and anecdotal records of Broad Shelled Turtles nesting in the lower catchment (Reach 4). Snake-Necked Turtles tend to inhabit shallow lakes, floodplain billabongs and ephemeral waterbodies while Short Necked and Broad Shelled Turtles prefer permanent water with relatively stable water regimes and abundant cover from snags and instream vegetation (Cogger 2000, Jacobs 2019).

11.5 APPENDIX E: RISK OF ENVIRONMENTAL WATER DELIVERY TO LOWER BROKEN CREEK AND NINE MILE CREEK

Table 22: Risks and mitigation actions for delivering environmental water along the lower Broken Creek and Nine Mile Creek

Risk description	Likelihood	Consequence	Risk rating	Mitigation actions (lead agency)
Specified flow rates are insufficient to achieve the intended extent of wetland inundation or magnitude and duration of river flows, resulting in a failure to achieve planned environmental outcomes.	Possible	Major	Medium	<p>Include contingency allowance in estimated watering requirements, based on previous event data, and consider a contingency in the duration of the event to achieve desired wetland inundation. (CMA)</p> <p>Monitor event (especially for deliveries to new sites or for previously untested events) and adjust flows as necessary or terminate event if it becomes clear that insufficient water is available. (CMA)</p> <p>Identify and address constraints that may limit the flow rates for environmental deliveries. (CMA/GMW)</p>
Overestimates of environmental water demand prevents planning for supplying demands at other locations. Note: Planning watering actions also includes decisions around the carryover and trade of water as alternatives to current year water use decisions.	Possible	Minor	Low	<p>CMA review demand estimates and targets met by unregulated flows throughout the delivery cycle and regularly advise VEWH of any changes so unused water can be reallocated. (CMA)</p> <p>CMA review demand estimates at the conclusion of the watering year, prior to the development of the following seasonal watering proposal, so estimates of future requirements are more accurate. (CMA)</p> <p>River operators provide regular updates on flows, including through OAG meetings. (MDBA/GMW)</p> <p>Manage Water Holdings to maximise supply opportunities for all sites. (VEWH)</p>
Inaccurate accounting and measurement or operational error results in target flows either not being achieved or being exceeded, leading to a failure to achieve planned environmental outcomes.	Unlikely	Moderate	Low	<p>Review accounting and measurement processes to be used to ensure that techniques are agreed and monitoring/measurement sites are operational. (GMW)</p>
Environmental water account is overdrawn, leading to water not being available as per approved watering statement to complete planned actions and environmental benefits not being achieved. Note: Planning watering actions also includes decisions around the carryover and trade of water as alternatives to current year water use decisions.	Unlikely	Major	Low	<p>Monitor ABA balances and undertake regular communications with CMA and RWC as part of portfolio management activities. (VEWH)</p> <p>Ensure that deliveries are reported progressively throughout the event and are monitored against ordered volume. (CMA/GMW)</p>
Planned maintenance of water delivery infrastructure results in planned/specified flows not being achieved, leading to a	Likely	Minor	Low	<p>Undertake early planning and communications between the CMA and storage operator to minimise likelihood of constraints, enable scheduling of maintenance outside of high demand periods or identify alternative</p>

Risk description	Likelihood	Consequence	Risk rating	Mitigation actions (lead agency)
failure to achieve planned environmental outcomes.				environmental water delivery windows to avoid scheduled maintenance activities. (CMA/GMW) Consider adding time contingencies to planned maintenance schedules to ensure works are completed prior to commencement of watering actions. (CMA)
Failure of poorly maintained environmental delivery infrastructure results in planned/specified flows not being achieved, reducing the ability to achieve planned environmental outcomes (including failure or damage due to vandalism).	Likely	Moderate	Medium	Asset ownership is clarified, and the asset owners perform regular maintenance, and prevent asset inspections, on delivery infrastructure. <i>*Note that insufficient resources are likely to limit the asset owner's ability to regularly inspect and maintain infrastructure. Increased resources for these activities may further reduce the likelihood and risk ratings.</i> (Asset owner) Report vandalism to police. (Asset owner) Review asset design to minimise opportunities for interference or damage. (Asset owner) For privately owned assets, arrange approvals to use/operate assets and undertake pre-delivery inspections. (CMA) Communicate failures to the CMA. (Asset owner) Initiate documentation of asset ownership and management arrangements in national parks. (PV) Consider monitoring options to detect vandalism, interference or failure of assets at individual sites with elevated risk. (Asset owner)
Poor condition of delivery infrastructure results in the asset owner being unable to operate the structure due to OH&S risks, leading to failure to deliver environmental flows and to achieve environmental objectives. Note: This issue may affect multiple sites. GMW to confirm OH&S status and likelihood rating.	Likely	Moderate	Medium	Asset owner to undertake regular maintenance and pre-event asset inspections on delivery infrastructure. (Asset owner) <i>*Note that insufficient resources are likely to limit the asset owner's ability to regularly inspect and maintain infrastructure. Increased resources for these activities may further reduce the likelihood and risk ratings.</i> Communicate failures to the CMA (Asset owner). Develop design for new regulating structure and seek funding to implement necessary upgrades in conjunction with asset owner. (CMA/ MDBA in Barmah Forest) Note: PV proposing to issue operating licences for BMF regulators.
High operational and consumptive water demands lead to reduced access for environmental deliveries, with the result that target flows/volumes cannot be achieved, impacting on environmental outcomes.	Low	Minor	Low	Event planning will seek to avoid peak demand periods, and events will be monitored and adjusted as necessary. (CMA/GMW) System operators to provide longer term forecasts for future consumptive demands as an input to planning watering proposals (GMW/MDBA) Develop longer term agreements on river capacity access for environmental deliveries. (VEWH) Investigate opportunities to undertake deliveries outside the irrigation season with

Risk description	Likelihood	Consequence	Risk rating	Mitigation actions (lead agency)
				consideration of appropriate delivery costs. (CMA/VEWH)
High downstream demands may lead to flows that exceed local environmental requirements and targets (including rates of river rise and fall), leading to negative environmental outcomes, including negating previous environmental improvements.	Almost Certain	Major	Extreme	<p>Monitor the effectiveness of adopted seasonal flow limits for river systems, with annual negotiation and management of release plans and reviews during the season as required. (VEWH/DEECA)</p> <p>Monitor impacts of new trade limits and revised operating rules and review as necessary. (DEECA/ Goulburn Broken CMA)</p> <p>Coordination of downstream e-water demands with regard for upstream impacts to balance impacts and benefits. (VEWH/SCBEWC)</p>
Environmental water deliveries result in low dissolved oxygen (DO) levels, with adverse environmental impacts. Note: Advice is that annual leaf litter accumulation is sufficient to cause risk, even if previously inundated.	Unlikely	Moderate	Low	<p>Where possible implement a full annual suite of flow components in river systems, including those designed to control build of organic matter (such as winter flushes). Plan deliveries with consideration of high temperature periods where appropriate. (CMA)</p> <p>Develop monitoring and response plans and reserve contingency volumes in delivery plans for dilution flows if DO concentrations drop to levels of concern. (CMA)</p> <p>Monitor leaf litter loads and avoid exceeding any flow thresholds likely to create hypoxic black water events, where possible and considering temperature drivers. (CMA)</p> <p>Assess new/proposed actions for DO impact potential and adjust watering plans as needed. (CMA)</p>
Environmental water deliveries may generate or mobilise BGA blooms, with adverse water quality and/or health impacts (including to people, livestock and pets), resulting in cessation of releases and environmental impacts.	Possible	Major	Medium	<p>Consider likelihood of initiating BGA blooms in event planning and amend as required to manage risk, including investigating alternate delivery paths - e.g. lower outlets/offtakes, or non-delivery (e.g. as per 2022 for lower Broken creek). (CMA/CMA)</p> <p>Land managers or water corporation implement a monitoring program during environmental watering events, and where issues are identified, activate BGA response processes. (Land mgr./GMW)</p> <p>*Note: Parks Victoria’s BGA risk management plan for Northern Victoria Region that considers the potential risk of environmental water events is currently awaiting final approval. This plan outlines proactive and reactive monitoring and management responsibilities that Parks Victoria commits to as a Local Waterway Manager for BGA. Adequate BGA resourcing is considered as part of this plan.</p> <p>Regional monitoring and advice on BGA status. (GMW)</p>
Insufficient information and knowledge available to inform environmental water deliveries.	Unlikely	Moderate	Low	<p>Identify important knowledge gaps and secure funding to improve scientific understanding. (CMA)</p> <p>Consider deferring deliveries until sufficient information is available to mitigate unacceptable risks. (CMA)</p>

Risk description	Likelihood	Consequence	Risk rating	Mitigation actions (lead agency)
				Implement adaptive management processes and undertake trials to collect data. (CMA)
Environmental deliveries improve conditions for non-native species (e.g. carp, invasive species, feral horses) leading to adverse environmental impacts. Or pest plants and animals prevent environmental water outcomes being achieved.	Likely	Moderate	Medium	<p>Study/understand life history of species and develop high level management strategies. (DEECA)</p> <p>Develop and implement site specific management strategies aimed at eradication/control of existing populations (e.g. carp management strategy, willow removal program, waterlily spraying program, feral animal programs). (CMA/Land Mgr.)</p> <p>Implement pest reduction efforts prior to delivery of water, to ensure increases in populations remain within "tolerable" levels, e.g. consider adjusting timing and magnitude of flows to reduce carp impacts and check in with fish ecologists.</p> <p><i>(Note: This risk is still rated as medium after mitigation actions.)</i></p>
Environmental watering actions trigger non-targeted environmental responses (e.g. bird breeding) causing unintended consequences (or lost opportunities) for other environmental values.	Likely	Moderate	Medium	<p>Undertake monitoring and communicate these issues as they arise and apply adaptive management and review of delivery plans. (CMA)</p> <p>Consider including contingency allowance in delivery plan water volumes to complete breeding events. (CMA)</p>
Ineffective planning and/or uncoordinated water ordering results in administrative obstacles that prevent watering opportunities.	Unlikely	Moderate	Low	Enable the full range of watering actions possible in seasonal watering proposals and the seasonal watering plan (as per SWP guidelines). (CMA/VEWH)
Limited environmental deliveries may reduce opportunities to test ecological responses to environmental flows, impacting on effectiveness of research projects.	Unlikely	Minor	Low	Review monitoring program and adjust if possible. Reprioritise future flow targets. (CMA)

Adapted from Lower Broken Creek Seasonal Watering Proposal 2023-24 note residual risk to be determined.

**11.6 APPENDIX F: MAPPING OBJECTIVES TO BASIN PLAN EWP OBJECTIVES, SCHEDULE 7
TARGET GROUPS, BWS QEEO, AND LTWP VIC MURRAY OBJECTIVES.**

** indicates that the LTWP objective is relevant, but that Lower Broken Creek is not listed against this objective in the LTWP.

Table 23: Mapping objectives of the lower Broken Creek

		Basin Plan Schedule 7 Targets to measure progress - from 1 July 2019 there is improvement in:						Basin Wide Environmental Watering Strategy - Relevant Expected Environmental Outcomes				Victorian Murray Long-term Watering Plan - relevant objectives				
Basin Plan objective (Chapter 8, Environmental Watering Plan)		Flow regimes i.e. progress towards natural flow regimes.	Hydrologic connectivity b/w the river and floodplain and between connected valleys	Condition of Priority Environmental Assets and Priority Ecosystem Functions	Condition, diversity, extent and contiguousness of native water-dependent vegetation	Recruitment and populations of native water-dependent species, including vegetation, birds, fish and macroinvertebrates	The community structure of water-dependent ecosystems.	River flows and connectivity	Native vegetation	Waterbirds	Native fish	Vegetation	Waterbirds	Fish	Other	
8.05 - Protection and restoration of water-dependent ecosystems	8.05,3(a) An objective is to protect and restore biodiversity that is dependent on Basin water resources by ensuring that: water-dependent ecosystems that support the life cycles of a listed threatened species or listed threatened ecological community, or species treated as threatened or endangered (however described) in State law, are protected and, if necessary, restored so that they continue to support those life cycles.	Flow supports lifecycle of listed species	Connection between creek and Murray River for listed species to move	Condition of refugia, longitudinal pathways and feeding/breeding/nursery habitat for listed species.	Aquatic plants as shelter for listed species and to support food sources (macroinvertebrates).	Recruitment of listed species	Age class distribution of threatened species				Refer to native fish outcomes - below			LTWPM14 Improve abundance of large-bodied native fish. LTWPM17 Improve habitat for native fish. LTWPM18 Maintain species richness of native fish.		
8.06 - Protection and restoration of ecosystem functions of water-dependent ecosystems	8.06,2 An objective is that the water quality of Basin water resources does not adversely affect water-dependent ecosystems and is consistent with the water quality and salinity management plan.	Flow maintains water quality	Dilution flows to Murray River in some instances								Refer to native fish outcomes - below				LTWPM24 Maintain water quality within an appropriate range to allow for ecosystem processes	
	8.06,3(a) An objective is to protect and restore connectivity within and between water-dependent ecosystems, including by ensuring that: the diversity and dynamics of geomorphic structures, habitats, species and genes are protected and restored.	Flow supports protection of species diversity. Unable to support geomorphology.	Connection between Creek and Murray River supports gene movement, propagule/seed movement.	Breeding habitat and longitudinal pathways support species/gene diversity.		Direct link re: diversity of vegetation	Direct link re: protecting species diversity	Direct link re: protecting species diversity				Refer to native fish outcomes - below			LTWPM17 Improve habitat for native fish. LTWPM18 Maintain species richness of native fish.	LTWPM21 Improve habitat of turtle and crayfish communities. LTWPM23 Improve number of macroinvertebrate functional groups present.
	8.06,3(b)(i) An objective is to protect and restore connectivity within and between water-dependent ecosystems, including by ensuring that: ecological processes dependent on hydrologic connectivity: (i) longitudinally along watercourses; are protected and restored.	Flow supports longitudinal connectivity	Direct link re: longitudinal connectivity	Direct link re: longitudinal connectivity		Veg extent linked to longitudinal connectivity (dispersal pathway)	Direct link where recruitment relies on longitudinal connectivity.	Informed by longitudinal connectivity and what species can be supported.			B1.1 (longitudinal connectivity) - To keep baseflows at least 60% of the natural level.				LTWPM17 Improve habitat for native fish	
	8.06,6(a) An objective is to protect and restore ecosystem functions of water-dependent ecosystems that maintain populations (for example recruitment, regeneration, dispersal, immigration and emigration) including by ensuring that: flow sequences, and inundation and recession events, meet ecological requirements (for example, cues for migration, germination and breeding) is maintained.	Direct link - flow supports life-history stages	Direct link: longitudinal connectivity necessary for some life-history stages.	Condition of refugia, longitudinal pathways and feeding/breeding/nursery habitat supports life history stages.	Vegetation can influence life-history stages of other species		Direct link re: recruitment.	Informed by life-history stages being successful.				Refer to native fish outcomes - below			LTWPM17 Improve habitat for native fish	LTWPM21 Improve habitat of turtle and crayfish communities
	8.06,6(b) An objective is to protect and restore ecosystem functions of water-dependent ecosystems that maintain populations (for example recruitment, regeneration, dispersal, immigration and emigration) including by ensuring that: habitat diversity, extent, condition and connectivity that supports the life cycles of biota of water-dependent ecosystems (for example, habitats that protect juveniles from predation) is maintained.	Flows support habitat	Direct link: longitudinal connectivity and habitat connectivity.	Direct link re: habitat	Vegetation linked to habitat		Direct link re: recruitment.	Informed by habitat that supports life-history stages.				Refer to native fish outcomes - below		LTWPM4 Improve the extent of aquatic vegetation	LTWPM17 Improve habitat for native fish	LTWPM21 Improve habitat of turtle and crayfish communities
8.07 - Ensuring water-dependent ecosystems are resilient to climate change and other risks and threats	8.07,3 An objective is to protect refugia in order to support the long-term survival and resilience of water-dependent populations of native flora and fauna, including during drought to allow for subsequent re-colonisation beyond the refugia.	Flows support refuge	Connectivity allows access to refuge	Direct link re: refugia	Vegetation linked to quality and type of refugia.	Informed by availability of refugia	Informed by availability of refugia				Refer to native fish outcomes - below			LTWPM17 Improve habitat for native fish	LTWPM21 Improve habitat of turtle and crayfish communities	
	8.07,5 An objective is to mitigate human-induced threats (for example, the impact of alien species, water management activities and degraded water quality).	Flows help manage threats	Connectivity helps manage threats	Condition of refugia, longitudinal pathways and feeding/breeding/nursery habitat helps manage threats	Provides shelter to help manage impacts from alien fish species						Refer to native fish outcomes - below		LTWPM4 Improve the extent of aquatic vegetation	LTWPM17 Improve habitat for native fish	LTWPM21 Improve habitat of turtle and crayfish communities. LTWPM24 Maintain water quality within an appropriate range to allow for ecosystem processes.	
	8.07,6 An objective is to minimise habitat fragmentation.	Flows help reduce hydrologic fragmentation	Connectivity reduces fragmentation	Connectivity reduces fragmentation	Contiguous vegetation helps reduce fragmentation	Informed by degree of fragmentation	Informed by degree of fragmentation			B1.1 (longitudinal connectivity) - To keep baseflows at least 60% of the natural level.			LTWPM4 Improve the extent of aquatic vegetation	LTWPM17 Improve habitat for native fish	LTWPM21 Improve habitat of turtle and crayfish communities	

Native Fish	B4.1	Broad outcomes	No loss of native fish spp currently present within the basin
	B4.2		Improved population structure of key fish species through regular recruitment
	B4.3		Increased movement of key fish species
	B4.4		Expanded distribution of key fish species and populations
	B4.5		Improved community structure of key native fish species
	B4.6	Short-lived species	Restored distribution and abundance to levels recorded pre-2007
	B4.7	Moderate to long-lived species	Improved population structure (i.e. a range of size/age classes for all species and stable sex ratios where relevant) in key sites. This will require annual recruitment events in at least eight out of 10 years at 80% of key sites, with at least four of these being 'strong' recruitment events.
	B4.8		A 10-15% increase of mature fish (of legal take size) for recreational target species (Murray cod and golden perch) in key populations (<i>check spp relevant to Wimmera</i>)
	B4.9		Annual detection of species and life stages representative of the whole fish community through key fish passages; with an increase in passage of Murray cod, trout cod, golden perch, silver perch, Hyrtl's tandan, congolli, short-headed lamprey and pouched lamprey through key fish passages to be detected in 2019–2024; compared to passage rates detected in 2014–2019
	B4.10		Significant increases in the distributions of key species (see key fish spp table) in the southern Basin.