Thomson River Environmental Water Management Plan

West Gippsland Catchment Management Authority

June 2024

We acknowledge and pay our respects to the Traditional Owners of the region, the Gunaikurnai, the Bunurong, the Boonwurrung and Wurundjeri Peoples and pay respects to Elders, past, present and emerging.

Document history and status

Revision and distribution

Version no.	Description	Issued to	Issue date
1	First draft	Jennifer Hale, Paul Boon, Frank Amtstaetter, Stephanie Suter	various
2	Final draft	DEECA	21.06.2024

Management

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Name of document:	Thomson River Environmental Water Management Plan

Acknowledgements

Acknowledgement of Country

We acknowledge and pay our respects to the Traditional Owners of the region, the Gunaikurnai, their rich culture and spiritual connection to Country. We also acknowledge their responsibility to care for Country and pay our respects to Elders, past, present, and emerging.

Traditional Owner input and guidance on objectives and values was received from the Gunaikurnai Land and Waters Aboriginal Corporation (GLaWAC) via the Gunaikurnai Cultural Water Team.

Contributions to the development of the Thomson EWMP

The WGCMA would like to gratefully acknowledge the contribution of the following people in preparing the EWMP:

- Jennifer Hale, Paul Boon, Frank Amtstaetter – Thomson EWMP Technical Group
- Geoff Vietz and Jess Littlejohn, Streamology Waterway and Science Management – Thomson Environmental Flows Study
- Kate Austin and Brad Neale, HARC
- Geoff Vietz, Steve Clarke, David Crook, Paul Boon – Environmental Flows Technical Panel for Thomson Environmental Flows Study
- Thomson Project Advisory Group members (PAG/EWAG) including Rob Caune (VRFish), Chris Lamin (Native Fish Australia), Phil Taylor (Environment Victoria), Mike Kube and Barry Donahoe (Heyfield Wetlands Committee of Management), Jon Ryan (landholder), Norm Drew (landholder), Callum Stewart (Landholder), Bev Hookey (Landholder), Peter Minchella (Commercial fisher), Kris Leckie (VEWH), Kerry Matthews and Jolyon Taylor (Gippsland Water), Rob Yurisich (Melbourne Water), Matt Cook (SRW), Sean Marler (Whitehorse Canoe Club), David Stork and Elsa Burnell (WGCMA)
- Uncle Lloyd Hood and Timothy Paton, GLaWAC Cultural Water Officers

Glossary of terms and abbreviations

ARI	Arthur Rylah Institute for Environmental Research. The main delivery partner for VEFMAP
DEECA	Department of Energy, Environment and Climate Action The new Victorian government department established in early 2023 that is now responsible for the management of the state's water resources.
DELWP & DEPI	Department of Environment, Land, Water and Planning; Department Environment and Primary Industries (previous iterations of DEECA)
Ecological flow objectives	Measurable outcomes that are linked with the hydrologic management of environmental water. The achievement of ecological objectives should be able to be measured through monitoring programs. They may also be referred to as environmental objectives.
EFTP	Environmental Flows Technical Panel The technical panel is part of the broader project team and is comprised of scientists/engineers with expertise in the areas of vegetation, hydrology, fish biology and geomorphology. Their role is to undertake the technical assessments for the Thomson eflows project in order to determine the important flow requirements for the river.
EFRs	Environmental Flow Recommendations
Environmental flows	The flows required to maintain healthy aquatic ecosystems such as waterways, floodplains or wetlands. These flows reflect the needs of animals, plants, habitats and processes that are dependent on the specific hydraulic and physico-chemical conditions created with different flow events that help to maintain their ecological integrity.
Environmental water	Refer to *environmental flows*.
EWAG	Environmental Water Advisory Group - is the main forum for engaging with partners, stakeholders and the community around environmental water planning and delivery
EWR	Environmental Water Reserve An amount of water set aside specifically to benefit the aquatic ecosystem for which it is to be delivered. This water includes statutory environmental water entitlements (i.e. environmental water held in storages), minimum passing flows that are delivered from consumptive water entitlements held by urban and rural water corporations and unregulated flows and spills from storages.
EWMP	Environmental Water Management Plan A long term scientifically-based management plan that will set the ecological objectives and the watering regime required to meet these objectives. The EWMP will inform the Seasonal Watering Proposals that set the annual priorities for watering in that year.
Flow regime	The hydrologic pattern of flows that occurs in a waterway, floodplain or wetland influencing the hydraulics, ecology and geomorphology of that ecosystem. Flow regimes are typically described using flow events (e.g. fresh, bankfull flow), as well as the duration, timing, frequency and magnitude parameters. Natural flow regimes are those where there is no human intervention to the natural flow patterns for the system. Developed or regulated flow regimes are those where human intervention has altered the natural flow pattern. Intervention may include the presence of water storages or flow control points, the extraction of water, or the input of water.
Flow regulation	The alteration of the natural flow pattern in an aquatic ecosystem through the installation of water storages that control the hydrology of a range of incoming flows. The Thomson River is considered a regulated river system due to the presence of Thomson Dam and Cowwarr Weir.
FLOWS method:	A systematic, repeatable and scientific method provided by DEPI to determine the environmental water requirements for aquatic ecosystems in Victoria. The method was updated in 2013 following its original release in 2002.
Flow recommendations	One of the outputs of the FLOWS method. The recommendations describe the full suite of flow components that would be present under a natural flow regime for a system
Flow targets	Flow targets link the hydrologic objectives to a target site or reach. For example, an annual 5 day spring 800 ML/day fresh in Reach 3 of the Thomson River.
GLaWAC	Gunaikurnai Land and Waters Aboriginal Corporation

Thomson FLOWS study	The scientific study underlying the Thomson River EWMP. It implements many steps from the FLOWS method as well as stakeholder consultation to define and prioritise the flow requirements for the Thomson River and improve water management. The Thomson FLOWS study is the short form for the official project name; the Thomson River Environmental Flows and Management Review Project.
Management goals	A long term health goal or vision statement reflective of the water dependent values of the Thomson River.
MID2030	Macalister Irrigation District 2030 A project led by Southern Rural Water to modernise the water supply to the Macalister Irrigation District (MID). This is via a combination of pipelining and channel automation to achieve water savings, improve supply service and enable increased productivity in the MID.
PAG	Project Advisory Group A representation of stakeholders in the community linked to environmental water, and more broadly, water management within the Thomson River.
SRW	Southern Rural Water The company responsible for rural water supply for the Thomson-Macalister catchment. They are the storage managers for Lake Glenmaggie, Maffra Weir and Cowwarr Weir.
VEFMAP	Victorian Environmental Flows Monitoring and Assessment Program – large-scale, long-term monitoring program designed to assess ecosystem responses to changes in flow regime in regulated Victorian rivers that receive environmental water.
VEWH	Victorian Environmental Water Holder An independent statutory organisation that works with Catchment Management Authorities (CMAs) and Melbourne Water to ensure that Victoria’s environmental water entitlements are effectively managed to achieve environmental outcomes.
Water dependent values	Components of the ecosystem that are dependent on water provided from the river for critical life history stages or maintenance of its ecological integrity. Values may be a species, a community, a place of natural value, a process or habitat.
WGCMA	West Gippsland Catchment Management Authority The waterway manager for all waterways within the West Gippsland region, including the Thomson River. The WGCMA is also the project manager for this project and a key stakeholder.

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Executive Summary

The Thomson River Environmental Water Management Plan (EWMP) is a guiding document that sets out long-term (5-10 years) environmental watering goals, objectives and water regime required to meet set objectives. Development of the Thomson River EWMP has been led by the West Gippsland Catchment Management Authority (WGCMA) in consultation with delivery partners, stakeholders and Traditional Owners.

This document outlines the:

- Partnership and consultation undertaken for EWMP preparation and implementation
- Asset overview and characteristics
- Water-dependent environmental values present
- Water-related threats to environmental values
- Management goals for the asset
- Environmental objectives, targets and values that environmental watering of the asset will support or improve
- Watering requirements needed to meet environmental objectives
- Environmental water delivery infrastructure, management and constraints
- Risks associated with environmental delivery
- Outcomes intended to be demonstrated through monitoring and assessment, and
- Knowledge gaps to address.

The main purpose of this document is to inform environmental water management in the Thomson River (Carran Carran), guiding annual and multi-year environmental water planning, providing information to support seasonal watering proposals, water management and reporting obligations.

The Thomson River EWMP has been developed using the principles identified in the established vision statement for the Thomson system:

A living river, from mountains to sea, that sustains social, cultural and ecological values, contributing to the health and prosperity of the Gippsland lakes and broader region

The EWMP draws on guidance from multiple data sources including the overarching West Gippsland Regional Waterway Strategy (WGCMA, 2014), DEECA EWMP guidelines (DELWP, 2022), the Thomson FLOWS study (Streamology, 2020), technical studies, management plans and community input.

This plan sets out a flow management template to maintain or improve the ecological health of the Thomson River, identifying where environmental water (and flow management) can make contributions to flow components to achieve flow requirements that support various ecological values.

It is intended that this document will remain dynamic, with information updated to reflect the best available information regarding the Thomson River system, the environmental entitlement, ecological condition, and Traditional Owner knowledge and objectives.

The key values and objectives are summarised in Table 1.

Table 1 Thomson EWMP key values and objectives summary

Value	Landscape scale Objectives
Fish	Restore populations of native fish, specifically Australian grayling, through provision of spawning and migration cues Enhance the structure of native fish communities through provision of instream habitat
Macroinvertebrates	Maintain the natural invertebrate community
Birds and frogs	Maintain the existing frog population and provide suitable habitat* Provide freshwater habitat for migratory and non-migratory wetland birds within the Gippsland Plains landscape*
Platypus	Increase the abundance of platypus
Vegetation	Maintain the structural diversity and appropriate distribution (zonation) of streamside vegetation along the riverbank and reduce terrestrial encroachment/invasion (Thomson River) Increase the recruitment and growth of native in-stream, fringing and streamside vegetation (Thomson River) Maintain the existing vegetation and promote the growth, establishment and resilience of semi-aquatic species (Heyfield wetlands)
Geomorphology	Maintain the physical form of the channel to provide a variety of channel features and habitats for aquatic animals Enhance river function by maintaining substrate condition and enabling carbon cycling
Water quality	Improve water quality in the Thomson estuary

*Values and objectives related to Heyfield Wetlands

Engagement

Various stakeholders, partners and community groups have been engaged through the development of both the Thomson FLOWS and this subsequent EWMP to determine key water-dependent values, objectives and targets in the Thomson system.

The Thomson Environmental Water Advisory Group (EWAG) is the main forum for engaging with partners, stakeholders and the community around annual environmental water planning and delivery. Membership of this group originated from the Thomson flows study project advisory group (PAG), with subsequent membership coming from an expression of interest process designed to target a diverse range of communities of interest. This group is composed of members from government agencies, environmental groups, as well as landholders/irrigators, recreational users, and land managers. There is also Traditional Owner membership of the EWAG, however the current preferred engagement method is for the WGCMA and the Gunkaikurnai Land and Waters Aboriginal Corporation (GLaWAC) Cultural Water team to meet separately to discuss watering proposals and cultural objectives.

Table 2 summarises the engagement that has occurred in the development of the Thomson EWMP.

Table 2 Thomson EWMP engagement summary table

<table>
<tr><th>Stakeholder(s)</th><th>Engagement method</th><th>Engagement purpose</th></tr>
<tr><td>• VEWH
• Melbourne Water
• Southern Rural Water
• Thomson river irrigators
• Gippsland Water
• Heyfield Wetlands Committee of Management
• Recreational fishing community
• VR Fish
• Whitehorse canoe club</td><td>• Formal advisory group, Thomson PAG/EWAG
• Direct engagement (one-on-one)</td><td rowspan="2">• Input into the Thomson Flows study, including foundation work around values and objectives identification
• Data sharing
• Review and feedback on approach and target setting for EWMP
• Provides a forum for building knowledge and capacity of members, groups to contribute to proposed annual and multi-year watering actions and intended outcomes.
• Assist in increasing awareness and understanding of the purpose of objectives of the environmental watering program in the Thomson system.
• Identify opportunities to achieve shared benefits.
• Increase collaboration and awareness of the Thomson catchment.</td></tr>
<tr><td>• Gunaikurnai Land and Waters Aboriginal Corporation</td><td>• Direct engagement (one-on-one)</td></tr>
<tr><td>• Arthur Rylah Institute</td><td>• Direct engagement (one-on-one, monitoring programs)</td><td>• Representation on the project Steering Group
• Sharing observations and monitoring data</td></tr>
</table>

Introduction

The Thomson River Environmental Water Management Plan (EWMP) has been prepared by the West Gippsland Catchment Management Authority (WGCMA) to establish the long-term (i.e. 5-10 years) environmental watering goals, objectives and the water regime required to meet the set objectives for the Thomson River system. The purpose of the EWMP is to:

- Describe the site, location, environmental values, condition and threats, management objectives and the watering regime required to achieve these objectives.
- Describe the hydrology of the system and any environmental water delivery infrastructure and complementary actions that are required, as well as knowledge gaps and recommendations
- Identify the long-term ecological targets, objectives and water
- Inform annual and multi-year environmental water planning, delivery, and reporting
- Describe the most effective use of the Thomson River Environmental Entitlement 2017 based on the best available evidence
- Provide an avenue for community and Traditional Owner consultation
- Guide short and long-term decision making associated with water resource and waterway management in the Thomson River system

The EWMP will serve as a guiding document for the WGCMA, Victorian Environmental Water Holder (VEWH) and the Department of Energy, Environment and Climate Action (DEECA) and reference point for the community.

The aspects that are in scope and out of scope for the Thomson EWMP are detailed in Table 3.

Table 3 Items within and outside of the scope for the Thomson EWMP

In scope	Out of scope
• Thomson River reaches from downstream Thomson Reservoir to the Thomson-Latrobe confluence • Description of the water dependent values and ecological condition of the system – including those related to Heyfield Wetlands • Establishment of ecological objectives, targets • Identification of knowledge gaps, constraints, opportunities and monitoring requirements to enable continual improvement	• Thomson River upstream of Thomson Reservoir • Detailed consideration of environmental benefits to the Gippsland Lakes and wetlands • Comprehensive ecological condition assessments on water dependent flora, fauna and ecosystems • Specific watering requirements for Heyfield Wetlands

EWMP Development Process

The Thomson River EWMP was prepared using input from:

1. **Technical FLOWS study**: The Thomson River Environmental Flows and Management Review updated the environmental flow recommendations for the Thomson River in 2020, based on current ecological, hydrological and hydraulic modelling information. This study has also consolidated these inputs to describe the ecological condition of the system, and make an assessment of priorities, monitoring requirements and knowledge gaps.
2. **Heyfield Wetlands**: The Heyfield wetlands Environmental Water Requirements report was completed in 2022 with the Heyfield Wetlands Committee of Management, outlining the

management objectives and watering regime requirements for the site. As Heyfield wetlands receives environmental water deliveries from the Thomson Environmental Entitlement, values and objectives related to this site have been considered in this EWMP.

3. **Updated hydrologic modelling**: In 2023, the watering scenarios (i.e. drought, dry, average, wet) were reviewed and updated for the Thomson, providing a more up-to-date approach for estimating annual water availability to inform annual water planning, based on both inflow probability and likelihood of reservoir spilling. A 2D model was also developed for reaches 4 – 6 to test the updated flow recommendations and provide a better understanding of relationships between flow, and ecological and geomorphic processes.
4. **Project Advisory Group (PAG) and Environmental Water Advisory Group (EWAG):** the PAG was originally established for input to the Thomson FLOWS project. This group has evolved into the Thomson River EWAG, and is the main forum for engaging with partners, stakeholders and the community around environmental water planning and delivery. The group was engaged through workshop updates and feedback sessions on different elements of the plan development.
5. **Expert Technical Panel**: Directly involved in the content creation, assessments and technical input into the EWMP
6. **Traditional Owner engagement:** As part of the Thomson FLOWS development, along with annual water planning, the WGCMA and GLaWAC have discussed options and opportunities for increased participation and inclusion of Gunaikurnai Traditional Owner input and collaboration in the ingoing management of environmental water to support and improve the *Carran Carran* (Thomson River).

Consultation

Consultation for the Thomson River EWMP, summarised in Table 4, was undertaken through the following avenues:

- An established **Environmental Water Advisory Group (EWAG)** that consists of representatives from a broad range of stakeholder groups associated with the Thomson River, including government agencies, environmental groups, landholders/irrigators, recreational users, and land managers. There is also Traditional Owner membership of the EWAG, however GLaWAC's current preferred engagement method is for the WGCMA and the GLaWAC Cultural Water team to meet separately to discuss watering proposals and cultural objectives. The EWAG was engaged through workshop updates and a specific discussion and feedback session to review the values, targets and objectives that informed plan development.
- An **Expert Panel** consisting of technical experts in fish, vegetation, hydrology and flow-ecology relationships were directly involved in the development and review process of the EWMP
- **GLaWAC** – through Water Program Officers, Uncle Lloyd Hood and Timothy Paton. Information was shared between the WGCMA and GLaWAC through the completion of the Thomson and Latrobe flows studies. While aware of the Thomson EWMP process, GLaWAC did not have the capacity at the time to input directly in development. Also, noting this is an evolving space, and as capacity and resourcing allows GLaWAC would like to take the lead on preparing cultural objectives and values for waterways and the broader region.

Table 4 Membership and role of the groups involved in EWMP development

Group	Membership	Role in EWMP development
Thomson EWAG	Southern Rural Water (SRW) Melbourne Water (MW) Victorian Environmental Water Holder (VEWH) Gippsland Water (GW) Thomson River irrigators & landholders Heyfield Wetlands Committee of Management (HWCoM) Recreational fishing community VR fish Native Fish Australia (NFA) Whitehorse Canoe Club	**Provided input on**: • Water dependent values and targets • Vision statement • Ecological and flow objectives • Opportunities for improvement • Knowledge gaps • Review of proposed watering actions for annual planning (Seasonal Watering Proposals)
Gunaikurnai Land and Waters Aboriginal Corporation (GLaWAC)	Traditional Owners – GLaWAC Cultural Water Officers EWAG	• Cultural input – objectives and values in FLOWS for the Thomson, Macalister and Latrobe rivers • Review of annual planning processes (Seasonal Watering Proposals) • Consultation around monitoring and other NRM opportunities in the Thomson region
Project Expert Panel	Arthur Rylah Institute Jennifer Hale Consulting Dodo Environmental (Heyfield Watering Plan, Project technical Panel for EWMP) WGCMA **Other technical input contributors**: HARC (modelling) Alluvium (modelling) Streamology Pty Ltd (Thomson FLOWS Study)	• Project oversight and direction • Project timeline management • Engagement with EWAG and GLaWAC • Technical reports and data capture/sharing • Draft EWMP – compilation and review

Traditional Owners

The Gunaikurnai Land and Waters Aboriginal Corporation (GLaWAC) have Registered Aboriginal Party (RAP) status under the *Aboriginal Heritage Act (2006)* and their area of determination covers all current West Gippsland rivers that receive environmental water. The WGCMA has had a Memorandum of Understanding (MoU) in place with GLaWAC since 2013. In this MoU the WGCMA agrees to involve the Aboriginal corporation in all WGCMA projects from the beginning, as well as to build capacity of GLaWAC to protect and conserve natural resources.

In terms of engagement around environmental water management, this usually takes place via in-person meetings with GLaWAC Cultural Water Officers to review proposed flows and cultural objectives, values and uses. However, due to recent capacity constraints at GLaWAC this specific method of engagement has not occurred, however strategic engagement between the WGCMA and GLaWAC occurs regularly.

WGCMA has worked closely with GLaWAC on previous planning documents and will follow the same guiding principles and approach to include and consider cultural values and objectives in annual water planning. This content was recently reviewed and approved as part of the Seasonal Watering Proposal process.

Asset Overview

Catchment Setting

The Lake Wellington catchment extends from Lake Wellington to the slopes of the Great Dividing and Strzelecki Ranges. It includes almost 1.2 million hectares of land in the catchments of Latrobe, Thomson, Macalister and Avon Rivers and runs from Noojee and Warragul in the west to Stratford in the east. Lake Wellington is the most westerly of the Gippsland Lakes and forms part of the Gippsland Lakes Ramsar site, a wetland complex of international conservation significance. Three of the four major rivers in the catchment are regulated (Latrobe, Thomson, and Macalister rivers) and each have an environmental water entitlement. A fourth environmental water entitlement is held to divert water to the lower Latrobe wetlands (i.e. Dowd Morass, Heart Morass and Sale Common) (Figure 1).

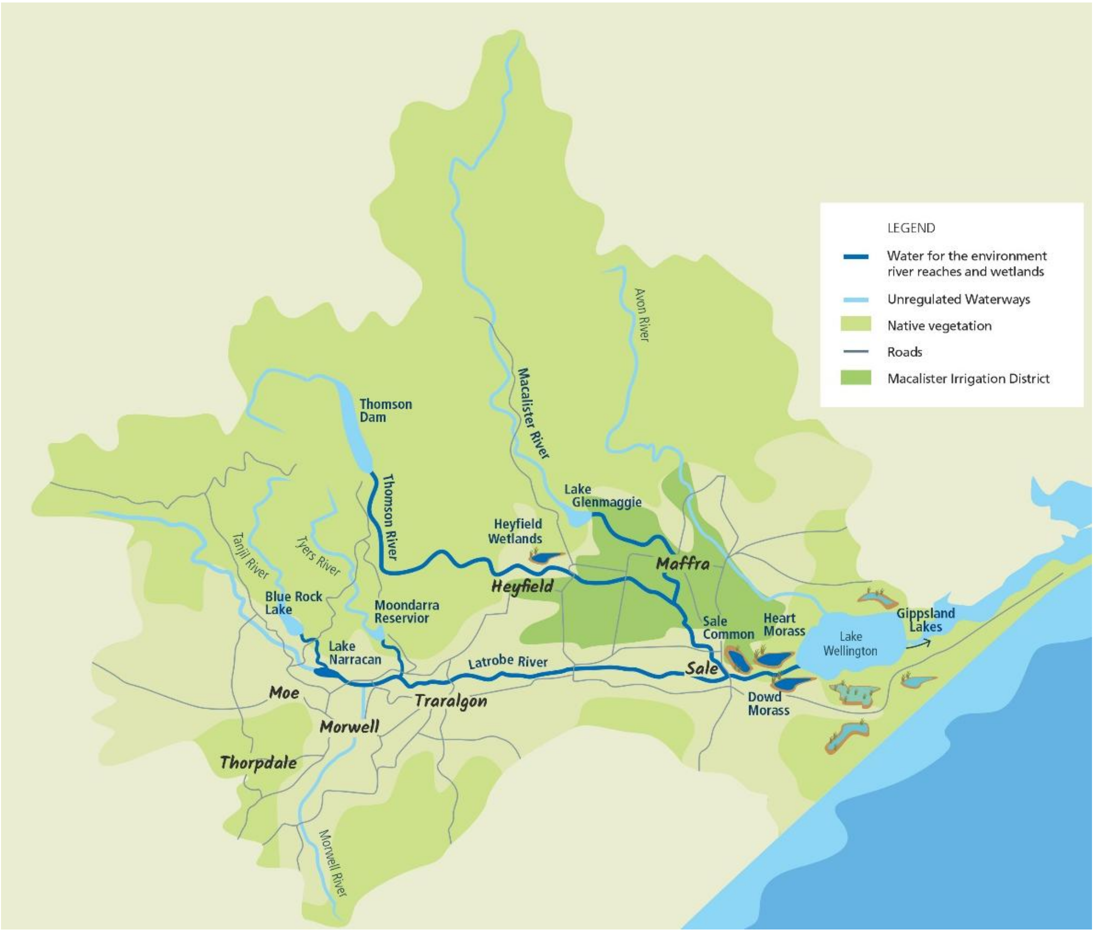


Figure 1 Map of the Lake Wellington Catchment, with environmental water receiving rivers and wetlands highlighted (dark blue)

With a continued connection to Country spanning more than 27,000 years, the Gunaikurnai are the Traditional Owners over much of Gippsland with approximately 1.33 million hectares extending east-west from near Warragul to the Snowy River and north-south from the Great Dividing Range to the coast and sea country (GLaWAC, 2015). The Lake Wellington catchment includes the Macalister River (Wirn wirndook Yeerung), Thomson River (Carran Carran), Latrobe River (Durt'Yowan) and the lower

Latrobe Wetlands, and forms part of the Country of the Brayakaulung people – whose clan area extends from the current site of Sale, Providence Ponds, Avon and Latrobe rivers; west of Lake Wellington to Mounts Baw Baw and Howitt (Figure 2).

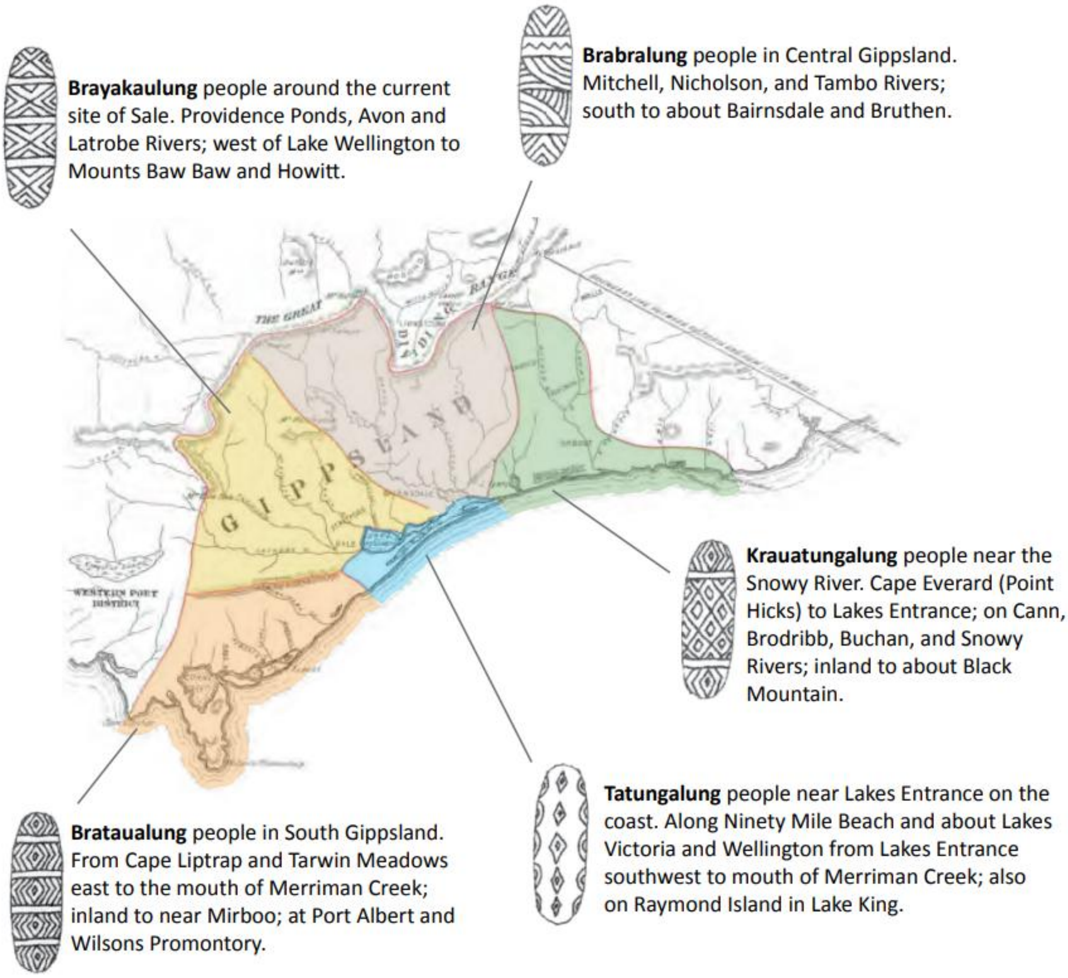


Figure 2 Gunaikurnai Five Clans, from the GLaWAC Whole of Country Plan (2015)

The river was originally referred to as the Carran Carran by Gunaikurnai peoples. It was given its English name in 1840 (Streamology, 2020).

Thomson River System

The Thomson River catchment drains an area of 1,522 km^2 extending from Mt Gregory (1,011 m) in the Victorian Alps bioregion, to downstream of Sale, where it joins the Latrobe River in the Gippsland Plains bioregion. Two major structures exist on the Thomson River: Thomson Reservoir (the major potable water storage for metropolitan Melbourne) and Cowwarr Weir (a regulating structure providing irrigation water to the Macalister Irrigation District) (WGCMA, 2023)(Figure 3).

In the upper catchment, river flow is regulated by the Thomson Reservoir, significantly altering the natural flow regime. Environmental water is managed via water holdings held and released from the

Thomson Reservoir. Below Thomson Reservoir, the main tributary inflows for the Thomson come from the Aberfeldy River in the upper reaches, and the Macalister River in the lowest reach.

For management purposes, the Thomson River has been divided into 6 reaches, based on major characteristics such as hydrology, land use, landform, riparian vegetation (Figure 3).

- **Reach 2:** Thomson Reservoir Wall to Aberfeldy River Junction
- **Reach 3:** Aberfeldy River Junction to Cowwarr Weir
- **Reach 4a:** Thomson River, Cowwarr Weir to Rainbow Creek Confluence
- **Reach 4b:** Rainbow Creek, Cowwarr Weir to Thomson River Confluence
- **Reach 5:** Reach 4a/4b Confluence to Macalister River Confluence
- **Reach 6:** Macalister River Confluence to the Latrobe River

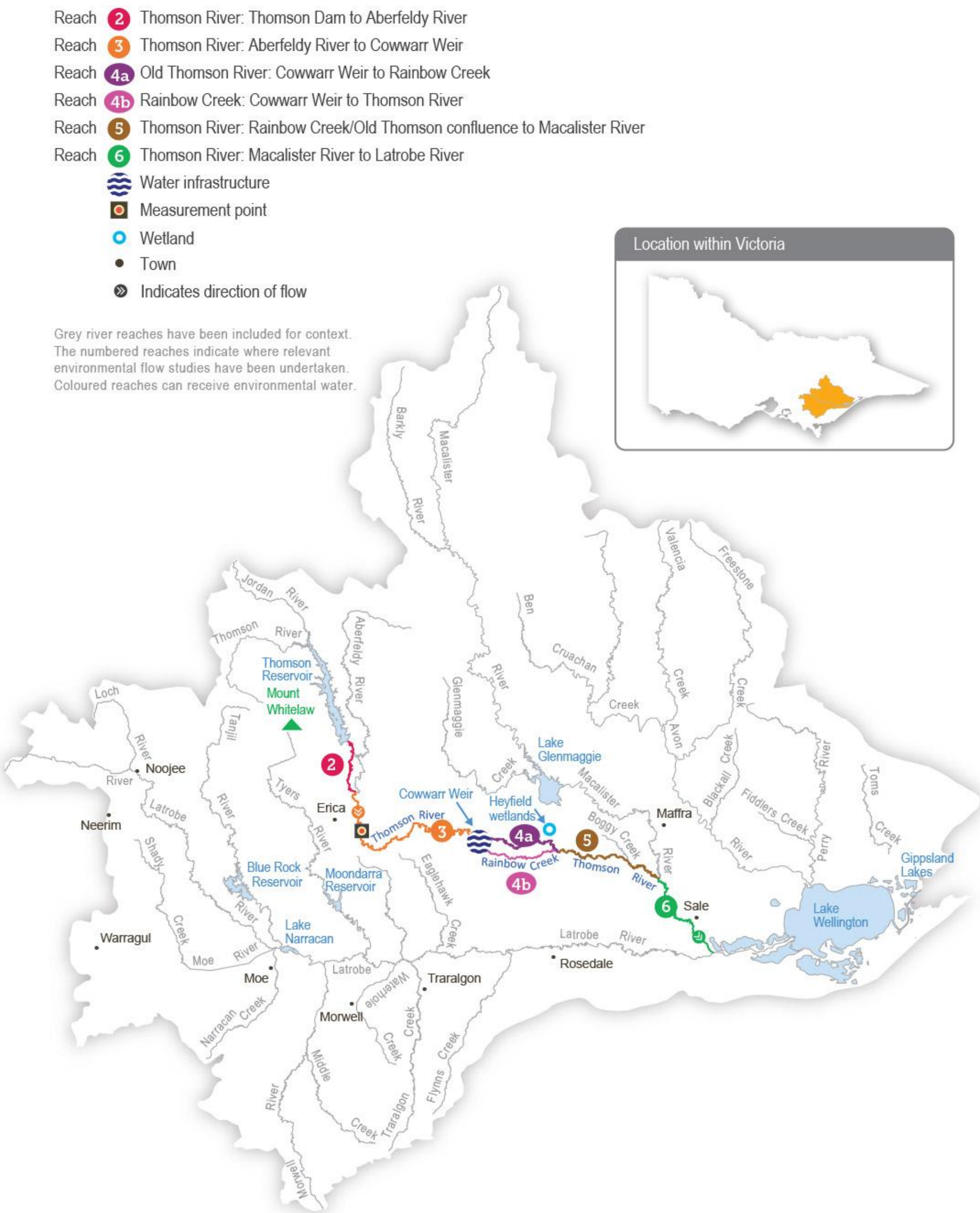


Figure 3 Thomson River reaches & Heyfield Wetlands, areas the EWMP covers (from VEWH, 2019)

Immediately downstream of Thomson reservoir, and confined within the hillslopes of the Eastern Highlands, are Reaches 2 and 3. Reach 2 contains high-value water-dependent vegetation, and since 2019 has had fish connectivity restored through the Horseshoe Bend Fishway on Reach 3. Horseshoe Bend fishway reconnects the Thomson with upstream reaches in the Victorian Alpine bioregion, unlocking an additional 22 km of waterway to fish passage, as well as access to an additional 64 km of the Aberfeldy River (Figure 4).

Figure 4 Aerial view of the Thomson Fishway at Horseshoe Bend

Reach 3 (from Aberfeldy River to Cowwarr Weir) has **heritage river status** under the *Heritage Rivers Act 1992*, with largely intact native riparian vegetation communities and fish populations, including the protected Australian grayling.

Inflows from the Aberfeldy augment flows and sediments into Reach 3. In addition to the Horseshoe Bend fishway, connectivity with lower reaches has been improved since 2003 via the installation of a fishway at Cowwarr Weir. The lower section of Reach 3 is a transition zone between the uplands and lowlands of the catchment, characterised by a loss of energy creating a depositional environment in the form of an alluvial fan, upon which the Rainbow Creek avulsion was formed. Rainbow Creek is a relatively new waterway, in that it formed in the 1950s following a series of flood events on the Thomson River that carved a new flow path (avulsion). The development of Rainbow Creek had a significant impact on the farming communities of Cowwarr and Heyfield districts, and changed the way water is managed following the construction and operation of Cowwarr Weir in 1957-1959 (Figure 5). Without active management of flow at Cowwarr Weir, Rainbow Creek would be the preferred flow path of the Thomson River (WGCMA, 2020).

Figure 5 Cowwarr Weir on the Thomson River

Cowwarr Weir is the second major flow regulation structure of the Thomson River. At Cowwarr Weir, the river splits into the old river course (Reach 4a, 29kms) and Rainbow Creek (Reach 4b, 14 kms). Passing flows throughout the year are split two-thirds down Reach 4a and one-third down Reach 4b to avoid impacts to irrigators located on Rainbow Creek. The outlet at Cowwarr Weir for Reach 4b is a low-level offtake valve with no fishway and acts as complete barrier to the migration of fish and other aquatic fauna and inhibits the transport of sediment and plant propagules through this reach (Streamology, 2020). With this impediment in place, water for the environment is preferentially delivered through Reach 4a to support fish migration.

Below this point, the river channel is laterally unconfined, meandering, with floodplains on either side of the channel (Streamology, 2020). Stony Creek is a small tributary of the Thomson River, joining the river approximately 2km downstream of Cowwarr Weir.

The Heyfield wetland complex (Figure 6), adjacent to the Thomson River (Reach 4a), is a cluster of freshwater pools near the township of Heyfield, sustaining significant vegetation, providing refuge for migratory bird species and an important site for recreation. The wetlands are seen to aid in decreasing turbidity and nutrient loads in the Thomson River, and ultimately the Gippsland Lakes Ramsar Site, by filtering stormwater and agricultural runoff. The wetlands have received environmental water deliveries since 2019 (WGCMA, 2023).

Figure 6 Aerial view of Heyfield Wetlands

Reach 4a and Reach 4b converge near Heyfield, forming Reach 5. Reach 5 consists of a meandering sand bed channel with high sinuosity and abandoned channels. Native fish assembly is largely intact, with Reach 5 having the highest abundance of large-bodied fish (Streamology, 2020).

Reach 6 represents the section of the river below the Macalister confluence and upstream of the confluence with the Latrobe River, downstream of Sale at the Swing Bridge (Figure 7) (WGCMA, 2023). Reach 6 contains ecologically significant freshwater wetlands which are hydrologically disconnected from the river. Reach 6 is also used to assess the continuity of environmental flow releases down the system and is a known spawning location for Australian grayling (Streamology, 2020).

Figure 7 Downstream of the confluence of the Latrobe River (left hand side) and the Thomson River (right hand side)

Land status and management

The entire length of land along the Thomson River from Cowwarr Weir to the confluence with the Latrobe is approximately 231 km, with a large proportion of this being Crown frontage. The majority of Rainbow Creek flows through private land. The floodplain and agricultural land of the Thomson-Rainbow system is highly productive, forming part of the Macalister Irrigation Area, the largest irrigation district south of the Great Dividing Range (WGCMA, 2014). Reach 4a and 4b supports 144 diverters with a total licensed allocation of 35,479 ML/year.

The Heyfield Wetlands are jointly managed by DEECA and the Heyfield Wetlands Committee of Management, with onsite plantings and works funded through grants focusing on improving the water quality entering the Gippsland Lakes. The wetlands are also an important environmental feature of the area as the surrounding land is used for industrial and agricultural purposes with nearby rivers harvested for irrigation. The Heyfield wetlands serve as a refuge for wetland and migratory bird species, a feature which is lacking in the immediate surrounding landscape. Since 2019, this site has received environmental water deliveries to support vegetation and habitat objectives (WGCMA, 2023).

Melbourne Water and Southern Rural Water manage the main infrastructure on the Thomson River, and Gippsland Water manage the watering infrastructure for Heyfield Wetlands. There are formal operating arrangements in place between the delivery partners (i.e. VEWH, WGCMA, water corporations) that guide environmental flow ordering, communications, reporting and deliveries in the Thomson system.

Asset Characteristics and Regional Significance

The Thomson River is in the WGCMA's Gippsland Lakes and Hinterland Landscape priority area, with the Gippsland Lakes being recognised for high social, economic, environmental, and cultural value to the region. Lake Wellington and its rare freshwater fringing wetlands are part of the Gippsland Lakes Ramsar site, recognised for their significant coastal wetland features, including vital habitat for migratory bird species (WGCMA, 2014).

Flowing over 200 km in a south-easterly direction, the Thomson spans the Victorian Alps bioregion, the Highlands bioregion, and the Gippsland Plains bioregion. From Thomson Dam downstream to Cowwarr Weir, the Thomson has been designated as a Heritage River recognising values related to scenic landscapes, cultural heritage sites, native fish species, and recreational opportunities.

Table 5 Summarised Asset Characteristics

Characteristics	Description
Name	Thomson River (Carran Carran)
Length (km)	216 (includes above Thomson Reservoir) 162 (below the Reservoir)
Bioregion/s	Victorian Alps Highlands Gippsland Plains
Conservation Status	Heritage River (Reaches 2-3)
Water Supply	*Thomson River - Environment (BE) 2005*
EVCs	*Upper reaches*: EVC 18 (Riparian Forest) EVC 29 (Damp Forest) EVC 39 (Montane Wet Forest) EVC 56 (Floodplain Riparian Woodland) EVC 82 (Riverine Escarpment Shrub) *Mid-Lower Reaches:* EVC 56 (Floodplain Riparian Woodland)

	EVC 55 (Plains Grassy Woodland) EVC 45 (Shrubby Foothill Forest) EVC 19 (Riparian Shrubland) EVC 132 (Plains Grassland) EVC 259 (Plains Grassy Woodland/Gilgai Wetland Mosaic) EVC 335 (Billabong Wetland Aggregate) EVC 681 (Deep Freshwater Marsh) (includes Sale Common)
Regulating structures/storages	Thomson Reservoir Cowwarr Weir

Environmental Water Sources

WGCMA is authorised to use water made available by the VEWH under the Bulk Entitlement (BE) *Thomson River - Environment* (Victorian State Government 2017a). The Water holder is entitled to a storage capacity of 18 GL. This is made up of the first 10 GL of inflow from the Thomson Basin and 3.9% of all inflow to the Thomson Reservoir.

Under the BE, passing flows are intended to meet both the environmental needs of the Thomson River and irrigation needs below Cowwarr Weir, and are specified as instantaneous flow at Beardmores gauging station, at the Narrows gauging station and at Coopers Creek gauging station. The Aberfeldy River is a tributary of the Thomson River and joins the Thomson River downstream of the Beardmores and the Narrows passing flow compliance points, and upstream of the Coopers Creek passing flow compliance point. This means that unregulated flows in the Aberfeldy River contribute to meeting the Coopers Creek passing flow target.

SRW, under the Bulk Entitlement *Thomson Macalister - Southern Rural Water*, must provide a passing flow in the Thomson River and Rainbow Creek between Cowwarr Weir and Wandocka, either:

a) The lesser of 125 ML/day, and the natural flow; or

b) If the natural flow is less than 50 ML/day, 50 ML/day

WGCMA is also authorised to use water made available by the VEWH under the BE *Macalister River Environmental Entitlement* (Victorian State Government, 2017b). The water holder is entitled to 12.4 GL of high reliability water from Lake Glenmaggie as well as 6.2 GL of low reliability water from Lake Glenmaggie. Given the connected nature of these two river systems, environmental water delivered down the Macalister River also provides benefits to the Thomson River, downstream of the Thomson-Macalister confluence.

At the time of writing, the VEWH is applying for an additional environmental entitlement following a mitigation water assessment related to the MID2030 modernisation project. Environmental watering plans for the Thomson and Macalister rivers outlined that the volume of mitigation water required to offset the impact to these sites, resulting from the MID2030 modernisation project, which is 1,814 ML long-term annual average yield. The new entitlement will likely see 1,568.8 ML of high-reliability entitlement and 691.8 ML of low-reliability entitlement held in Lake Glenmaggie, to be used by the VEWH at the mitigation water sites (Reaches 5-6 of the Thomson River and Reach 2 of the Macalister River). This section will need to be updated to reflect the operating arrangements and final outcomes associated with this application.

Hydrological Regime and System Operations

Surface Water Hydrology

The impact of the Thomson Dam, constructed in 1983, on the natural water regime of the Thomson River means that much less water is released down the river than would have flowed in pre-dam times, as described in the FLOWS study (Streamology, 2020). Competing water demands from consumptive, irrigation and environmental water uses results in a water resource that is in high demand and very often these demands are mutually exclusive, meaning that water allocated to one particular use (e.g. supply of potable water to Melbourne) cannot then be used for another purpose (e.g. environmental flows to benefit the health of the river). Assessments completed through the Thomson FLOWS study indicate that 60% of water that would have flowed down the river before the Thomson Dam became operational in 1983 is now removed from the Thomson River system by current extraction for potable use and irrigation (Streamology, 2020).

The Thomson Dam is a dominant cause of hydrologic changes to the system, which is located upstream of Reach 2 (Figure 8). The Thomson Dam has a capacity of 1,068 billion litres and supplies water to Melbourne. Releases from the Dam to the Thomson River are regulated through the Thomson Hydro Station and/or via two release valves located downstream of the Dam.

Figure 8 Thomson Dam on the Thomson River

Major inflows to the Thomson River are the Aberfeldy River and Macalister River with smaller tributaries; Coopers Creek, Deep Creek and Stony Creek. Outflows from the system occur in Lake Wellington and Lake Victoria (not covered under this Study – below reach 6) with some minor outflows into the wetlands in the Sale area.

Rainbow Creek was formed in 1952 through floodplain processes, triggered by floodwaters in the Thomson River that carved a new flow path (avulsion) (flows of 85,000 ML/d), by 1956 the Rainbow was carrying the entire flow that had previously passed along the Thomson River. Cowwarr Weir was constructed in 1957 and its operation changed natural hydrological regimes, intercepting sediments and providing flow to both the Thomson River and Rainbow Creek. The flow split is in the order of 2:1 in favour of the Thomson River up to an inflow of around 500 ML/d, at which point a by-wash channel is opened to deliver more flow to the Thomson. When inflows to Cowwarr reach around 1000 ML/d the floodgates into Rainbow Creek are usually opened and the majority of flood flow is then carried by Rainbow Creek (WGCMA, 2020). Without active management of flow at Cowwarr Weir, Rainbow Creek would be the preferred flow path of the Thomson River.

The impacts of regulation on natural flow patterns are well documented within the Thomson River system, with a reduction in flows in winter and spring. Figures 9-12 show flow comparisons for Reach 3 and Reach 5 as examples of the differences in mean river flow from the unimpacted hydrology (pre-regulation) to the current hydrology (Streamology, 2020).

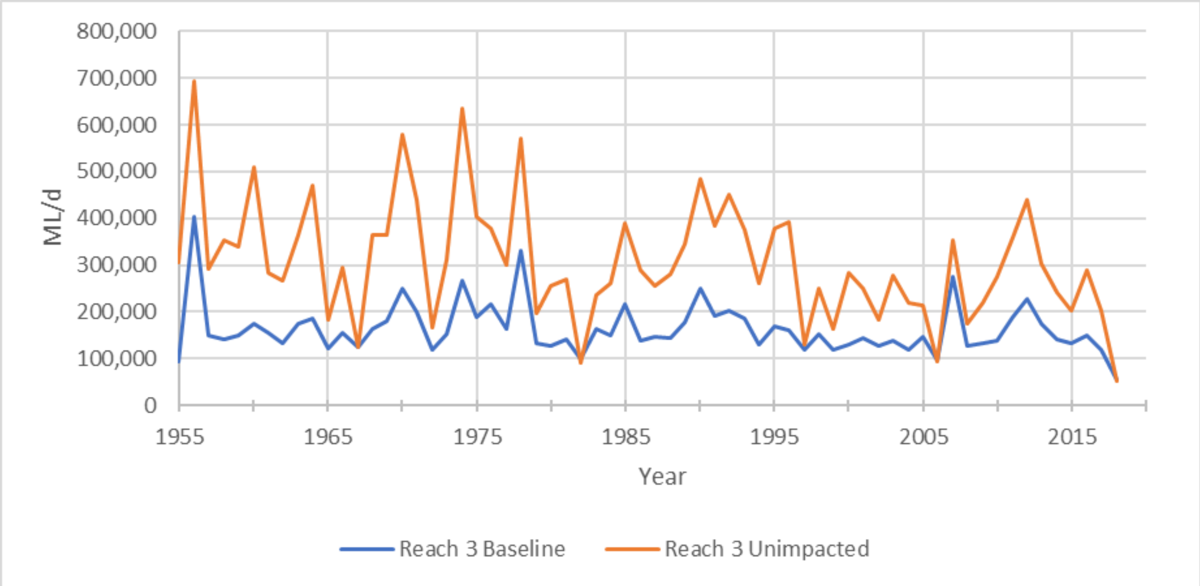


Figure 9: Reach 3 mean annual flow

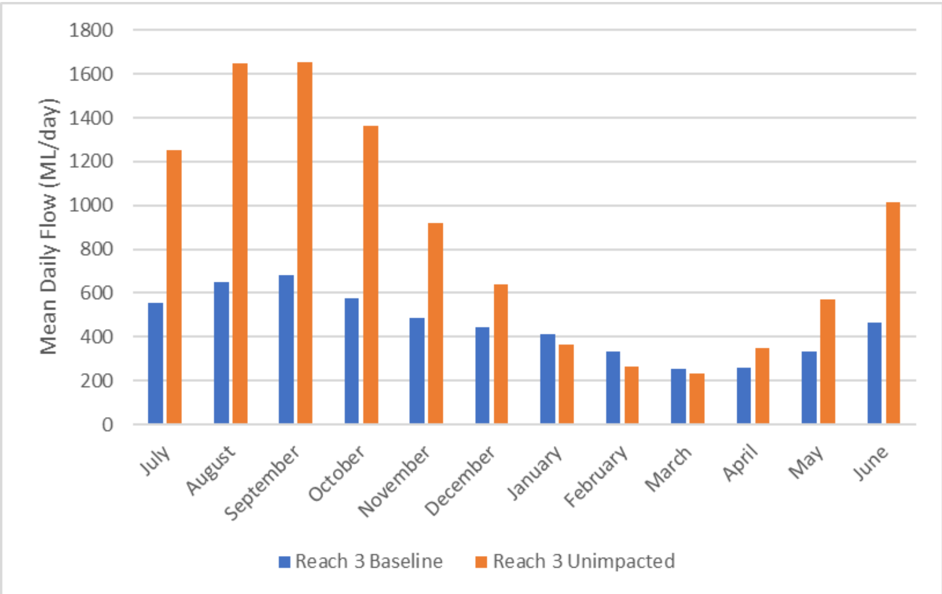


Figure 10: Reach 3 mean daily flows

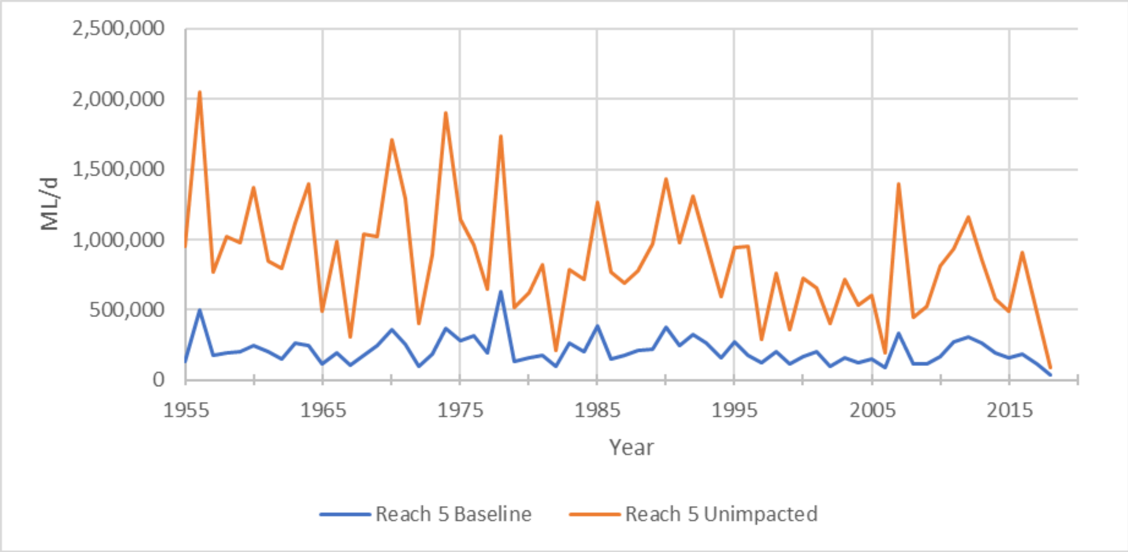


Figure 11: Reach 5 mean annual flow

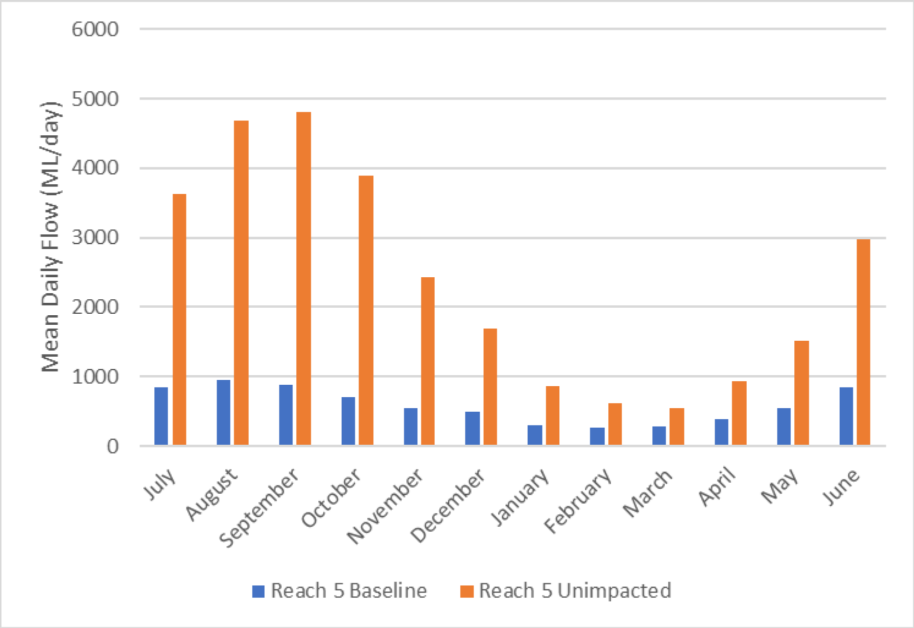


Figure 12: Reach 5 mean daily flows

Table 6 lists the percentage reduction in monthly flow after dam construction (post regulation) per reach of the Thomson River.

Table 6: Reduction in monthly flow after dam construction per reach (Streamology, 2020)

Reach	Reduction in monthly flow after dam construction
Reach 2 - Thomson Dam Wall to Aberfeldy River Junction	61%
Reach 3 - Aberfeldy River Junction to Cowwarr Weir	47%
Reach 4a - Thomson River, Cowwarr Weir to Rainbow Creek Confluence	7%
Reach 4b - Rainbow Creek, Cowwarr Weir to Thomson River Confluence	91%
Reach 5 - 4a / 4b confluence to Macalister River Confluence	75%
Reach 6 - Macalister River Confluence to the Latrobe River	43%

The Long-term Water Resource Assessment (LTWRA) reported that despite increases in water availability to environmental entitlements, the total volume available to the environment has still declined compared with historical availability. With current climate conditions and current water sharing arrangements, the average volume of water available to the environment in the Thomson-Macalister has decreased by 65.4 GL/year compared with historical availability (DELWP, 2020).

Groundwater

Three aquifers are located within the Thomson River footprint; the Quaternary alluvial aquifer along the valleys, the Boisdale Formation aquifer which dominates the Gippsland Plains extending south and east past Heyfield and the Palaeozoic basement aquifer, a shallow aquifer of fractured sandstone and mudstone in the highlands area of the Basin.

There are two Water Supply Protection Areas (WSPAs) relating to the Thomson River catchment, areas declared in the Water Act to protect groundwater resources with rules relating to equitable management and long-term resource sustainability. The Denison WSPA abuts the Thomson River and has a groundwater cap of 18,502 ML/yr; and the Sale WSPA covers the lower reaches of the Thomson River and has a groundwater cap of 21,212 ML/yr. Groundwater use in this area is mainly for the MID and these groundwater resources have low salinity (SRW, 2016).

A 2015 Study by GHD found that the Thomson River is largely dependent on regional groundwater discharge to streams, except possibly in the reach between Cowwarr Weir and Heyfield. The observed groundwater level and surface water level data at the Rainbow Creek gauge indicate consistent losing conditions, which is probably due to artificial maintenance of high stream water levels (above the watertable) via regulation at Cowwarr Weir (GHD, 2015). Downstream of Heyfield, the Thomson River exhibits mainly gaining baseflow conditions.

Water-dependent values

Environmental Values

As previously outlined, the upper reaches (Reaches 2-3) of the Thomson above Cowwarr Weir are listed as a heritage river under the *Heritage Rivers Act* 1992 and support high value vegetation and aquatic fauna.

The Thomson River is also one of a network of coastal rivers across Gippsland and south-eastern Australia that sustains populations of nationally significant migratory native fish species, including the Australian grayling, Tupong and Short- finned and Long-finned Eel (Streamology, 2020).

Combined river flows from the Thomson, Macalister and Latrobe rivers also support rare freshwater fringing wetlands in and around Lake Wellington, contained within the Gippsland Lakes Ramsar site.

As part of the 2020 FLOWS review, the following water dependent values were identified:

Biodiversity:

- Macroinvertebrates
- Fish
    - Diverse native fish assemblages. Species of particular significance include Australian grayling, Dwarf galaxias, Tupong, Australian bass, Short-finned eel and Long-finned eel.
- Crustaceans
    - Crayfish
- Vegetation
    - Microbial biofilms
    - Submerged vascular plants
    - Non-woody fringing vascular plants (e.g. reeds, rushes and sedges)
    - Woody and non-woody vegetation in channel, on benches and in lower riparian zone (maintenance of native water-dependent taxa and minimisation of encroachment by terrestrial plant species)
    - Water-dependent woody riparian trees and shrubs (e.g. Swamp Paperbark)
    - Terrestrial vegetation requiring a specific gully/valley microclimate (e.g. EVCs 18, 29, 39 and 56)
    - Freshwater floodplain wetlands
    - Floodplains
- Fauna
    - Platypus / Rakali
    - Birds

  - Frogs
  - Turtles
  - Gippsland Water Dragon

Ecosystem processes:

- Carbon and nutrient cycles
- Stream substrate condition
- Water Quality
- Channel form diversity (bed and bank)
- Floodplain wetland diversity

Ecosystem Type

The habitat types in the Thomson River system that can be influenced by environmental water include the perennial waterways from the Thomson Dam to the confluence of the Thomson River with the Latrobe River (reaches 2, 3, 4a, 4b, 5 and 6) and their associated floodplain wetlands. The Heyfield wetlands also receive environmental water. They are a series of constructed and rehabilitated wetlands largely on the site of the old Heyfield racecourse. Rehabilitation began in 1998 by the Heyfield Wetlands Committee of Management. The site now includes four main wetland ponds that receive a combination of stormwater and environmental water from the Thomson River to maintain wetland values and associated fringing shrubby vegetation (Figure 13). A watering regime for this site has been outlined in the Heyfield Wetlands Environmental Water Requirements report (Boon, 2022).

Figure 13. Heyfield wetlands in July 2021 (Boon 2022).

Vegetation

Vegetation includes aquatic macrophytes such as eel-grass (*Vallisneria australis*) and Water Ribbons (*Cycnogeton procerum*) and attached algae which, although often cryptic, play a major role in fueling the aquatic foods webs of the river. Fringing vegetation includes a range of emergent plants such as rushes, reeds, sedges and club-sedges, although the opportunity for colonisation by these types of plants is often limited by the fast-flowing water and the rocky substratum. Woody riparian vegetation is diverse and often thick and includes shrubs such as bottlebrushes (*Callistemon* spp.), hazels (*Pomaderris* spp.), tea trees (*Leptospermum* spp.), paperbarks (*Melaleuca* spp.) and wattles (*Acacia* spp.) as well as tall canopy trees such as Manna Gum (*Eucalyptus viminalis*), Swamp Gum (*Eucalyptus ovata*) and River Red Gum (*Eucalyptus camaldulensis*). Exotic trees such as willows (*Salix* spp.) are also present in some parts of the river, and the ground layer of the riparian zone often includes exotic and weedy species (e.g. blackberry *Rubus* sp.. and Wandering Trad *Tradescantia* sp.). As noted below, the condition and extent of riparian vegetation changes markedly with different sections of the river, with an overall decreasing trend in extent and condition as one proceeds downstream.

The vegetation communities associated with the Thomson River have inherent biodiversity values as well as providing food and habitat to native fauna, aquatic and riparian. The two main Ecological Vegetation Classes (EVCs) that surround the river in the reach between Thomson Reservoir and Cowwarr Weir are widely distributed and have a Bioregional Conservation Status (BCS) of 'Least

Concern' (i.e. EVC 18 Riparian Forest and EVC 82 Riverine Escarpment Scrub). In contrast, other riparian EVCs in the more agriculturally developed middle and lower reaches, such as EVC 19 Riparian Shrubland along Rainbow Creek and EVC 56 Floodplain Riparian Woodland along the Thomson River between Cowwarr Weir and Heyfield, are listed as 'Endangered' in the Gippsland Plain bioregion. Fringing and riparian vegetation plays a critical role in the overall condition of the Thomson River by stabilising the riverbank, shading the water and thus controlling temperature shifts, contributing organic-carbon sources such as leaf litter to fuel aquatic food webs, and providing coarse woody debris, such as tree branches, into the river as animal habitat (Boon et al. 2005, Capon and Dowe 2007, Alluvium 2011).

Riverine Vegetation

There is a stark difference in the extent and condition of native vegetation between the upstream reaches of the Thomson River (above Cowwarr Weir) and the lower plains. The section between The Thomson Reservoir and Cowwarr Weir has a riparian zone mostly of EVC 18 Riparian Forest (Least Concern) and bordering it, on the terrestrial side, EVC 29 Damp Forest (Least Concern) and EVC 45 Shrubby Foothill Forest (Least Concern). Riparian and terrestrial forest cover along this part of the river is almost 100%. Downstream of Boola Boola State Forest and into Stony State Forest, EVC 82 Riverine Escarpment Scrub (Least Concern) is also present (Figure 14).

Figure 14: Thomson River near Cooper Creek campground. Photograph taken November 2019, P. Boon.

Downstream of Cowwarr Weir, however, the surrounding landscape is almost totally cleared for agriculture and the riparian zone is much reduced (Figure 15). Along the mainstem of the Thomson

River between Cowwarr Weir and the township of Heyfield, only a narrow band of EVC 56 Floodplain Riparian Woodland (Endangered) remains. Alongside the Rainbow Creek anabranch, an even thinner remnant band of EVC 19 Riparian Shrubland (Endangered) is left with even smaller patches of EVC 56. A similar situation holds for the river between Heyfield and its confluence with the Macalister River, with only narrow and discontinuous patches of EVC 19 and EVC 56 remaining. Downstream of the confluence with the Macalister River the riparian zone becomes wider but is made up of the endangered EVC 56 but with some EVC 335 Billabong Wetland Aggregate (Endangered). Some EVC 681 Deep Freshwater Marsh is mapped to occur around the township of Myrtlebank, just north-west of Sale. This shift indicates the presence of some floodplain wetlands downstream of the confluence of the Macalister River, but little seems to be known about them. From Sale to the confluence with the Latrobe River, the riparian zone is again mostly narrow and fragmented, with EVCs 56 and 681 the most common types.

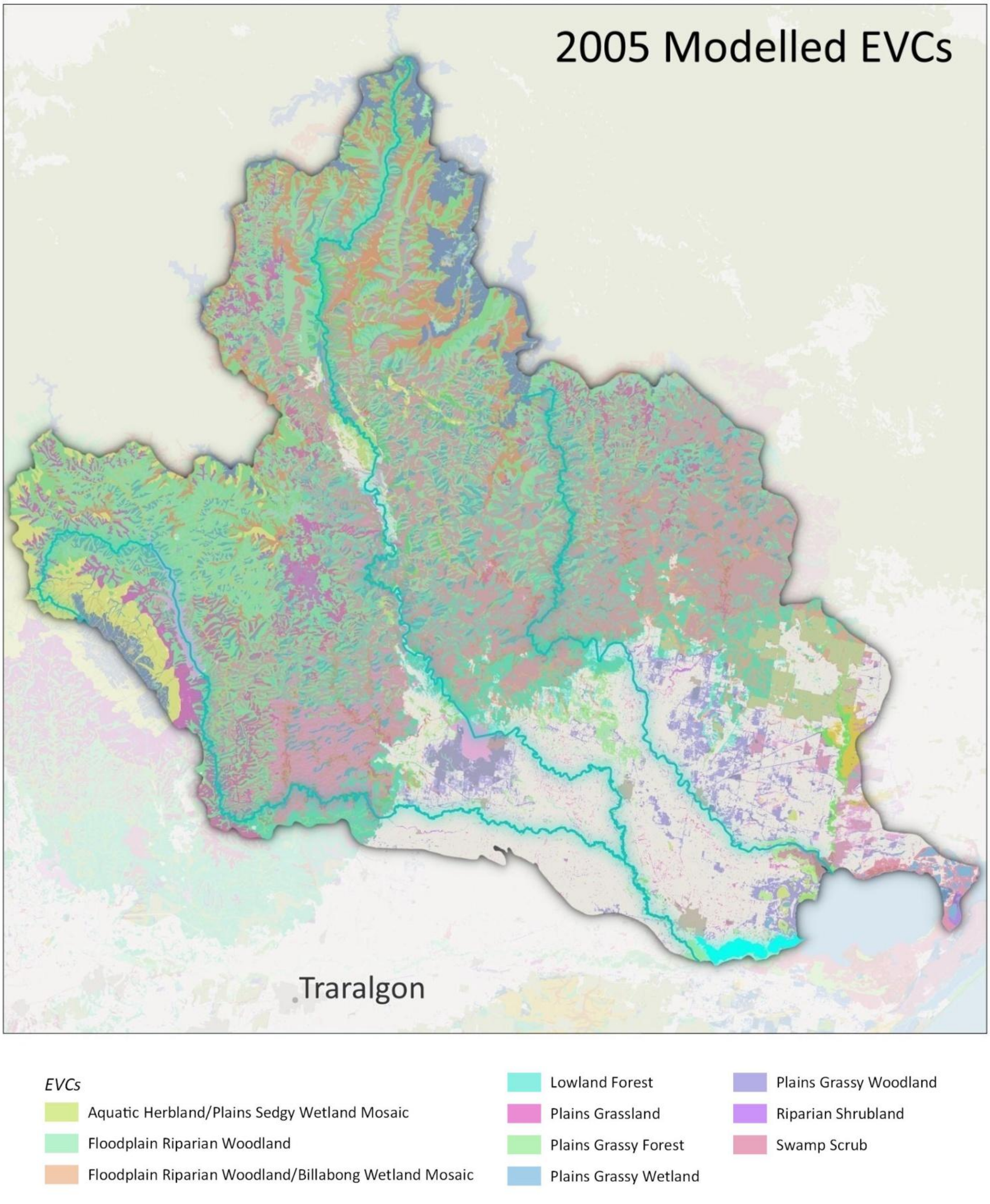


Figure 15. EVC (modelled 2005) mapping in the Thomson catchment.

Quantitative information on fringing and riparian vegetation is limited to surveys from three locations in a single reach (reach 4) from 2018/19. Jones and Vivian (2019) reported that the fringing vegetation was characterised by a high cover of inundation tolerant weeds such as blackberry (*Rubus anglocandicans*), reed canary grass (*Phalaris arundinacea*) kikuyu (*Cenchrus clandestinus*), wandering trad (*Tradescantia fluminensis*) and blue periwinkle (*Vinca major*) (Figures 16-17). The most common woody vegetation in the riparian zone was willow.

Figure 16. Fringing vegetation on the Thomson River at Cowwarr Weir in July 2028 (Jones and Vivian 2019).

Figure 17. Thomson River below Cowwarr Weir, showing ground layer dominated by the introduced Wandering Trad and Blue Periwinkle. Photograph taken November 2019, P. Boon.

Jones and Vivian (2019) reported that in-stream vegetation was present in shallow areas where there was little shading from riparian trees. Most commonly this was eel grass (*Vallisneria australis*) with occasional patches of pondweed (*Potamogeton* spp.). Emergent instream vegetation was a feature of reach 4, occurring as a narrow band at the foot of the bank, dominated by sedges and rushes such as river club-sedge (*Schoenoplectus tabernaemontani*) and marsh club-rush (*Bolboschoenus medianus*) (Jones & Vivian, 2019). Quantitative information on in-stream and fringing vegetation is lacking for other reaches of the river, although it is certain that it is present in many other parts of these reaches

(Figure 18). In the up-stream sections, high water velocity may be a limiting factor. In the most downstream sections, in-stream vegetation may be limited by poor water transparency and so may be constrained to the shallowest margins, where sufficient light penetrates the turbid water to support photosynthesis.

Figure 18. In-stream vegetation in the Thomson River near Cooper Creek campground. Photograph taken November 2019.

All reaches of the Thomson River were assessed as part of the Third Index of Stream Condition (DEPI, 2013). Data for this assessment were collected from 2004−2010, so are at least 15 years old and may be as much as two decades old. It is not clear the degree to which conditions have changed in the intervening period. The 2018 assessment used a different protocol to rate riparian vegetation, based on remote sensing of the entire reach, and thus is not directly comparable with the ground-truthed, single-site assessments undertaken in earlier ISC rounds.

The pattern predicted above with respect to variations among the different reaches in terms of the extent of various riparian EVCs was more-or-less confirmed by the 2010 ISC assessment. The highest streamside zone scores in the ISC were obtained for the most upstream reaches, those from the Thomson Reservoir to the confluence with the Aberfeldy River (score = 9) and from there to Cowwarr Weir (score = 8). Thereafter the streamside-zone scores dropped to between 5 (Cowwarr Weir to Heyfield) and 7 (confluence with the Macalister River to the confluence with the Latrobe River). The lowest score for the Streamside Zone was returned for ISC Reach 17, the Rainbow Creek anabranch, which was scored at 4 out of 10.

This downward trend in scores was reflected also in the overall condition scores, which ranged from 43 out of 50 ('Excellent') for the short reach immediately below the Thomson Reservoir (ISC Reach 5) to 31 ('Moderate') for the most-downstream reach, from the Macalister confluence to the Latrobe confluence. Perhaps surprisingly, Rainbow Creek received an overall score of 36, indicating 'Good' condition. This rating was received on the basis of high or very high scores for the Hydrology, Physical

Form, Water Quality and Aquatic Life sub-indices; scores for the Streamside Zone sub-index, at 4, was the lowest of the lot (Table 7).

Table 7. Index of Stream Condition Streamside scores (DEPI 2013, (DELWP, 2022)

FLOWS Reach number	ISC site number	Streamside Zone score (out of 10)	
		2010	2018
2	5	9	
3	4	8	7
4a	3	5	7
4b	17	4	
5	2	6	6
6	1	7	

Vegetation of the Heyfields Wetlands includes a wide range of open-water taxa such as water ribbons and water-milfoil (*Myriophyllum crispatum*), fringing rhizomatous taxa such as jointed twig-rush (*Baumea articulata*, now *Machaerina articulata*), club-rushes (*Bolboshoenus medianus*, *Bolboschoenus caldwellii* and *Schoenoplectus tabernaemontani*), common spike-rush (*Eleocharis acuta*) and several types of rush (*Juncus* spp.) The floating fern Azolla spp. may be common at times (Figure 19). Plantings of riparian trees and shrubs around the wetlands include drooping she-oak (*Allocasuarina verticittala*), river bottlebrush (*Callistemon sieberi*) and forest red gum (*Eucalyptus tereticornis*).

Figure 19. Billabong Wetland, Heyfield Wetlands. Photograph taken May 2022.

Native Fish

The Thomson River supports an ecologically diverse assemblage of native fishes, characterised by a high proportion of diadromous species: i.e., species that migrate between freshwater and the sea to complete their life history. Fifteen native freshwater fish species have been recorded from the Thomson River and associated wetlands, including the Australian grayling (*Prototroctes maraena*) and dwarf galaxias (*Galaxiella pusilla*) which are both listed as Vulnerable under the Commonwealth Environment Protection and Biodiversity Conservation Act 1999 (EPBC Act). Abundance from surveys in 2021 provides an indication of the status and distribution of freshwater fish in the system.

In addition to the native fish fauna, six introduced fish species have established populations in the Thomson River, including common carp (*Cyprinus carpio*), brown trout (*Salmo trutta*), rainbow trout (*Oncorhynchus mykiss*), redfin perch (*Perca fluviatilis*), gambusia (*Gambusia holbrooki*), goldfish (*Carassius auratus*) and roach (*Rutilus rutilus*) (Table 8).

Table 8. Native and introduced freshwater fishes recorded from the Thomson River. L = lower reaches, Longford to Cowwarr Weir; M = mid reaches, Cowwarr Weir to Horseshoe Bend; U = upper reaches, above Horseshoe Bend (Streamology, 2020). The abundance column refers to the total reported numbers of each species collected in the 2021 VEFMAP survey of the Thomson River (O'Connor, et al., 2022).*

Common name	Scientific name	Migration	Distribution	Abundance
River blackfish	*Gadopsis marmoratus*	Freshwater resident	L/M/U	46
Dwarf galaxias	*Galaxiella pusilla*	Freshwater resident	L	-
Flatheaded gudgeon	*Philypnodon grandiceps*	Freshwater resident	L	113
Dwarf flatheaded gudgeon	*Philypnodon macrostomus*	Freshwater resident	L	-
Southern pygmy perch	*Nannoperca australis*	Freshwater resident	L/M/U	79
Australian smelt	*Retropinna semoni*	Freshwater resident	L/M/U	2003
Short-finned eel	*Anguilla australis*	Catadromous	L/M/U	106
Long-finned eel	*Anguilla reinhardtii*	Catadromous	L/M/U	52
Common galaxias	*Galaxias maculatus*	Catadromous	L/M	122
Australian bass	*Macquaria novemaculeata*	Catadromous	L	25
Tupong	*Pseudaphritis urvillii*	Catadromous	L/M/U	359
Poached lamprey	*Geotria australis*	Anadromous	L/M/U	-
Short-headed lamprey	*Mordacia mordax*	Anadromous	L/M/U	1
Australian grayling	*Prototroctes maraena*	Amphidromous	L/M/U	20
Broad-finned galaxias	*Galaxias brevipinnis*	Amphidromous	M	-
Brown trout*	*Salmo trutta*	Freshwater resident	L/M/U	56
Rainbow trout*	*Oncorhynchus mykiss*	Freshwater resident	M/U	-
Redfin perch*	*Perca fluviatilis*	Freshwater resident	L/M	3

Common carp*	*Cyprinus carpio*	Freshwater resident	L/M	119
Goldfish*	*Carassius auratus*	Freshwater resident	L/M	2
Gambusia*	*Gambusia holbrooki*	Freshwater resident	L/M	31
Roach*	*Rutilus rutilus*	Freshwater resident	L	1

Native fish in the Thomson River can be broadly categorised according to their migratory characteristics:

Freshwater resident species complete their entire lifecycle in freshwater rivers and wetlands. These species do not migrate but can undertake local movements (e.g. in and out of wetlands or along rivers) to find food, mates or new habitats.

Catadromous species undertake downstream adult migrations out of the freshwater reaches of rivers to spawn in the estuary or sea. The juveniles then migrate upstream back into freshwater, where they grow and mature into adults. This group includes short and long-finned eels as well as Australian bass, common galaxias and Tupong.

Anadromous species undertake upstream adult migrations from the sea into the freshwater reaches of rivers to spawn. The juveniles often spend some time (1-2 years) in freshwater, before migrating downstream to the sea where they continue to grow and mature. This is a relatively uncommon life history strategy for Australian freshwater fishes but includes the two species of lamprey that have been recorded in the Thomson system.

Amphidromous species spawn in the freshwater reaches of rivers and the eggs and larvae drift downstream with the current into the estuary and, ultimately, the sea. After spending the early life stages (usually 4-6 months) in the marine environment, the juveniles migrate and disperse upstream into freshwater, where they grow and mature into adults. This is a relatedly common life-history strategy for Australian fish and includes the Australian grayling.

Macroinvertebrates

Macroinvertebrate assemblages are a vital part of the food chain for aquatic ecosystems as they form the basis of the diet of most native fish as well as platypus. Data from the Thomson River is limited and from more than a decade ago. It does indicate, however, a more diverse community in the upper reaches of the Thomson River reflecting the improved habitat condition when compared to lowland sites (Streamology, 2020). The community in the fast-flowing sections of the river immediately below the Thomson Dam is expected to be taxonomically diverse and include many species of Trichoptera (caddisflies), Plectoptera (stoneflies), Hemiptera (true bugs) and Diperta (flies). The macroinvetebrate community has high intrinsic biodiversity value, and is central to the structure and function of aquatic food webs, consuming allochthonous (e.g. leaf litter) and autochthonous (e.g. algal biofilms) sources of organic carbon and, in turn, being consumed as food by higher predators such as fish.

Platypus & Rakali

Platypus (*Ornithorhynchus anatinus*) are a top-order predator found in freshwater habitats along the east and southeast coast of mainland Australia and Tasmania. They are listed as vulnerable in Victoria under the Flora and Fauna Guarantee Act (FFG). Although data is limited, a recent e-DNA survey detected low abundances of platypus in all reaches of the Thomson

River downstream of Cowwarr Weir (Walker and Tingley 2023). The Great Australian Platypus Search Victoria (Griffiths et al. 2022) estimated the occupancy of the Thomson River basin by platypus at 15–20% but noted this was likely as underestimate as the e-DNA sampling sites were biased towards the lower reaches of the river. Recent e-DNA surveys carried out by WGCMA over 2023-24 detected presence of platypus DNA at 9 out of 10 sites along the Thomson River (Figure 20 eDNA Thomson River surveys 2023-24 (yellow markers indicate platypus DNA detections). Rakali weren't detected in the 2023-24 surveys and the latest VBA record was from 1992.

Figure 20 eDNA Thomson River surveys 2023-24 (yellow markers indicate platypus DNA detections)

Birds, reptiles and amphibians

Other vertebrate fauna that are supported by the Thomson River are more closely associated with the wetlands and floodplains of the system. Heyfield Wetlands represent the only aquatic ecosystems of these types that can be influenced with environmental water in the Thomson.

Regular monitoring of frogs and birds at the Heyfield Wetlands has shown they provide habitat for vulnerable frog species such as Growling Grass Frog (*Litoria raniformis*) and the Green and Golden Bell Frog (*Litoria aurea*). Ninety-two bird species have been recorded, including Great Egret (*Ardea alba*), Little Black Cormorant (*Phalacrocorax sulcirostris*) and Little Pied Cormorant (*Microcarbo melanoleucos*) (Boon, 2022).

Traditional Owner Cultural Values

Cultural Objectives and Environmental Water Linkages

While this document is for the planning of environmental water in a single system, the Gunaikurnai culture and identity is embedded in Country, with the land (Wurruk), waters (Yarnda), air (Watpootjan) and every living thing seen as one (GLaWAC, 2015). As such a whole of Country approach is more suitable when expressing Gunaikurnai values and objectives. In recognition of the Traditional Owner perspective of connected Country, and the connected nature of the *Durt'Yowan* (Latrobe), *Carran Carran* (Thomson), *Wirn wirndook Yeerung* (Macalister) rivers and lower Latrobe wetlands, the following will cover information that is shared across all rivers and wetlands that receive environmental water deliveries in West Gippsland.

GLaWAC's Cultural Water team have identified and shared both holistic and specific indicators and principles of river health when considering the management of environmental water and health of rivers and the estuaries:

- A **seasonal flow regime** with wet and dry periods is an important element of healthy Country
- Maintaining **water quality** is also a sign of healthy Country in the river and estuary reaches
- Providing **deep enough freshwater** in the wetlands to support appropriate habitat conditions for important plants and animals.
- Controlling **pest species** – important part of healthy Country
- Presence and health of keystone species: e.g. If *Boran* (pelicans) and *Tuk* (musk duck) are living and breeding there, it is a sign Country is healthy.
- It is important to maintain and restore freshwater habitat to support native fish populations for fishing and hunting. In particular, species of significance including *Noy yang* (eels), Australian Bass, River Blackfish, *Tambun* (Estuary Perch) and *Kine* (Black Bream), and crayfish.
- Many other reeds and grasses are also used for basket weaving; emergent vegetation is relevant to river reaches, the estuary and the wetlands
- Water quality indicators such as suspended solids and turbidity are also important across the river systems.
- Cormorants can be a good indicator of water quality – indicative of food availability, which in turn reflects water quality
- Native vegetation in the riparian zone is very important, including wattles (for multiple purposes and as part of the GLaWAC calendar)

Keystone species

The following is a list of some of the keystone species important to the Gunaikurnai, however it should be noted that the health of all native flora and fauna are important and should be considered in planning for environmental water:

- *Boran* (Pelican) *and Tuk* (Musk Duck) are significant totem species as highlighted in the Mother and Father song line within the Gunaikurnai creation story. If Boran and Tuk are living and breeding there, it is a sign Country is healthy. If they are not present, flows should be provided to promote required habitat/ecosystem services and Boran and Tuk will return.
- *Balagen* (Platypus) are also important keystone species. *Balagen* are considered an umbrella species, with their presence being a sign Country is healthy.
- *Loombrak* (Water Ribbons, *Triglochin sp*) is an important plant for food and basket weaving, as well as being a food source for animals and nesting areas for birds and habitat for fish and frogs.
- *Yeerung* and *Djeetgun* (Fairy wren) are also a totem species. While they are not considered water dependent and environmental flows may not directly support them, a diversity of flows supporting shrubs and riparian vegetation will provide habitat for fairy wren. For example, when flooding inundates wetlands, bush birds (including Yeerung and Djeetgun and other species) are known to increase in abundance and diversity.

Shared Benefits

Recreational Values

The primary purpose of water supply systems is for the reliable supply of water to entitlement holders for towns, industry, agriculture and environment. The storage, delivery and use of this water may also provide secondary, opportunistic socio-economic and cultural benefits. These benefits are recognised as shared benefits. Through the Water for Victoria plan, the Victorian government has committed to considering opportunities for shared benefits in water and waterway planning.

In West Gippsland, there are several known shared benefits provided by environmental watering. Table 9 summarises the Thomson River shared benefits as identified in the 2023-24 seasonal watering proposals.

Table 9 Thomson River shared benefits seasonal watering proposal review for 2023-24

Who?	Shared benefit
Canoe clubs, outdoor education companies, and recreational canoers/kayakers	Autumn, winter and spring freshes create ideal white water rafting conditions for avid canoers/kayakers in the upper Thomson.
Recreational bird watchers **Recreational duck/game hunters**	Deliveries to the Heyfield Wetlands provide habitat and attract waterbirds providing bird watching opportunities. Freshening flows from the Thomson, Macalister and Latrobe rivers all contribute to the health of the lower Latrobe wetlands. Freshes bring in waterbirds into these wetlands and provide both bird watching and game hunting opportunities, particularly in the lower Latrobe wetlands
Recreational fishers/anglers	Winter and spring freshes encourage the downstream migration and recruitment of Australia bass and estuary perch, both popular recreational fish species
Local and international tourists (including campers, hikers)	Flushing of waterholes and improved in-stream habitat with environmental watering events, provides high quality swimming and camping opportunities in the upper Thomson River, which is a popular location for recreational users
Landholders with river frontage & public land	Environmental watering contributes to the protection of riverbanks and land loss from erosion through the watering of riparian vegetation and maintenance of in-channel vegetation

Trajectory of Change

Geomorphology

The 2020 flows update study indicated that there was little change to channel and bed forms in the upper and lower reaches of the Thomson River (reaches 2,3, 5 and 6), which were described as being in good condition (Streamology, 2020). Reaches 4a and 4b, however, are continuing to degrade through avulsion. Reach 4a (Thomson River) is aggrading, which means that it will, overtime, fill in (Figure 21); while reach 4b (Rainbow Creek) is degrading through bed and bank erosion.

The FLOWS technical panel concluded that (Streamology, 2020):

"*The limited capacity of the Thomson River downstream of Cowwarr weir (Reach 4a), and the potential to control flows to Rainbow Creek (Reach 4b) will result in continuation of the current geomorphic trajectory: 4a aggrading and 'closing down' and 4b eroding*."

Figure 21. Thomson River downstream of Cowwarr Weir (Reach 4a) aggrading with sediments infilling the bed (photo Geoff Vietz, November 2019).

Vegetation

The original 2003 flows study (EarthTech, 2003) concluded the following with respect to vegetation change in the Thomson River, with a clear focus on the riparian zone:

- Encroachment (terrestrialisation) of vegetation on river channel in reaches 2 and 3.

- Willows and exotic grasses dominant in reaches 4a and 4b
- Loss of riparian and floodplain veg in reach 5 due to reduction in high flows
- Better riparian vegetation condition downstream of the confluence with the Macalister River.

Over the intervening two decades, it is unlikely that these observations have become irrelevant. Terrestrialisation is still a threat and has probably been ameliorated to some extent by the wetter-than-average period over 2021-2024. Once average or drier conditions return, let alone a prolonged very dry period such as drought, terrestrialisation of the stream bed by terrestrial species will likely recur in the upper and middle reaches. The presence of water in the thalweg at all times in the lower reaches probably precludes extensive terrestrialisation of the stream bed. However, many of the common riparian species, such as the *Melaleuca* paperbarks and the *Leptospermum* tea trees are adept at colonising a drying stream channel. More terrestrial taxa, such as Silver Wattle (*Acacia dealbata*), can also be aggressive colonisers should the stream channel become dry for extended periods. They, however, are readily drowned-out once wetter conditions return – for which a combination of adequate base flows and periodic prolonged freshes are required.

Willows are deeply problematic, as they are very invasive and spread via asexual means (e.g. by plant fragments). Exotic grasses are only a sub-set of the suite of existing and emerging weed problems, and many of herbs and forbs that already dominate the groundlayer are exceptionally difficult to control (e.g. Wandering Trad and Blue Periwinkle). Of the exotic grasses that are most troublesome, Reed Canary Grass is highly inundation-tolerant and thrives under shallow, permanent inundation.

The fourth claim by Earth Tech (2003) – that the riparian vegetation improved downstream of the confluence with the Macalister River – is not supported by the available evidence. As noted earlier in the section on vegetation, downstream of the confluence with the Macalister River the riparian zone does become wider than immediately upstream, but it is still dominated by the endangered EVC 56 and the best and widest riparian zones are found upstream of Cowwarr Weir. The important downstream change is that floodplain wetlands start to become more common compared with the more bedrock-constrained upper sections, and this is shown by the presence of EVC 335 Billabong Wetland Aggregate and EVC 681 Deep Freshwater Marsh around the township of Myrtlebank and further downstream. Climate-change would seem to present an existential risk to these types of wetland plant communities and the habitats they provide, as they are heavily dependent on regular (seasonal) overbank flooding.

There is no quantitative data on vegetation condition or trend for the Heyfield Wetlands, although the probable trajectory is one of improvement. This is because of the efforts in replanting and weed control by the committee of management. The recently wet conditions have probably also helped condition, and should drier times return the wetlands will be heavily dependent upon stormwater inputs and continuing environmental flows from the Thomson River.

Keeping the Thomson River flowing is a WGCMA initiative to improve native riverine vegetation in the lower reaches of the Thomson River. There is a planned program of fencing to remove stock from the riparian zone, removal of willows and revegetation with native species.

Fish

The status of fish assemblages in the Thomson River has been monitored intensively since 2005 as part of the DEECA established Victorian Environmental Flows Monitoring and Assessment Program

(VEFMAP). Monitoring provides not only quantitative information on the abundance, recruitment and population status of each species, but also the distribution, with monitoring occurring in all reaches downstream of the Thomson Dam. This data has underpinned the development of SMART targets for fish in the Thomson River.

Monitoring has indicated relatively stable abundances of most native fish species (2005 to 2021; see Appendix 2). For example, Australian grayling are most commonly observed in Reach 5 in the Thomson River, and abundance has remained steady for over 15 years of monitoring (Figure 22). Age structure (as measured by length) has indicated recruitment in most years (O'Connor et al. 2022).

One native fish species that has increased in abundance in recent years is Australian bass, which shows a sharp rise from 2011 onwards (Figure 23 Relative abundance (CPUE) of Australian bass captured in the Thomson River (2005-2021). Solid circles indicate mean CPUE values; open circles indicate individual site CPUE values (O'Connor et al. 2022).

This increase followed a targeted stocking campaign by the Victorian Fisheries Authority (VFA) where >65,000 fish were stocked in the Thomson River between 2010 and 2020. It is suggested that large numbers of YOY fish that were captured in 2019 and 2021 probably represent recently stocked recruits (O'Connor, et al., 2022).

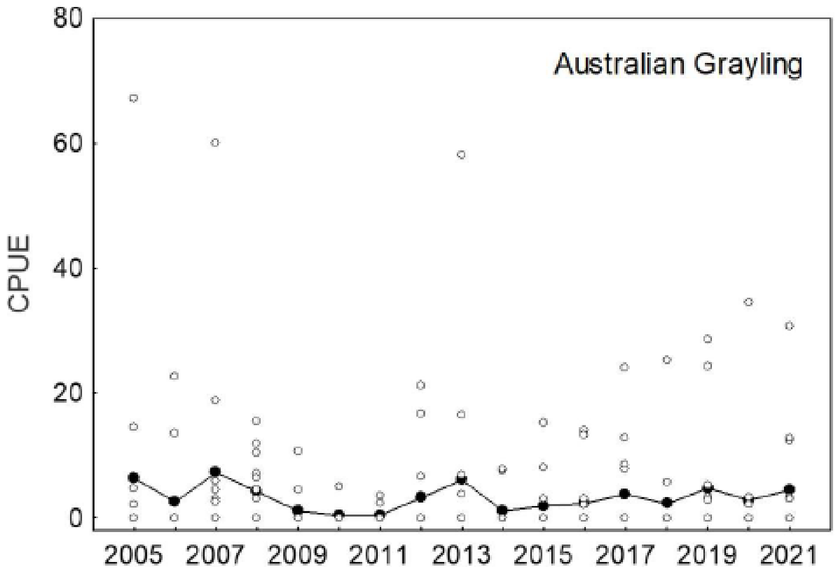


Figure 22. Relative abundance (CPUE) of Australian grayling captured in the Thomson River (2005-2021). Solid circles indicate mean CPUE values; open circles indicate individual site CPUE values (O'Connor et al. 2022).

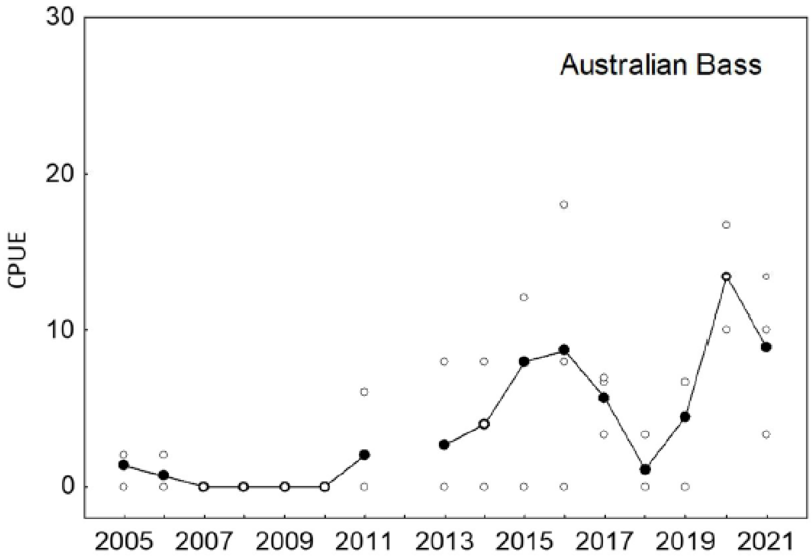


Figure 23 Relative abundance (CPUE) of Australian bass captured in the Thomson River (2005-2021). Solid circles indicate mean CPUE values; open circles indicate individual site CPUE values (O'Connor et al. 2022).

Other Biota

There is insufficient information about other values (e.g. macroinvertebrates, platypus, frogs, waterbirds) to determine any trajectory of change.

Managing Water-related Threats

Annual risk assessments are completed as part of preparing the seasonal watering proposals. These assessments involve waterway mangers, water corporations (as storage operators) and land managers, to identify potential risks that may occur in the upcoming water year that may prevent the objectives of environmental watering being achieved. The risks are considered in the context of proposed watering actions and the current conditions of environmental assets across the system.

The risk assessment itself is undertaken using the likelihood, consequence and risk rating tables contained in the Victorian Environmental Watering Program Risk Management Framework (VEWH, 2021).

Risks and mitigation strategies identified as part of the annual water planning process are shown in Appendix 3. Many of the risks were categorised as "low", with one "High" risk identified (related to safety risk around rapid changes to river conditions due to flow releases). All were assessed as having low residual risk levels following the application of the identified mitigations.

Management Goals, Objectives and Targets

The EWMP for the Thomson River is underpinned by a three-tiered hierarchy of objectives as follows (DEECA 2022):

- **A long-term (20+ year) vision** or management goal, consistent with the long-term aspirations of the West Gippsland Waterway Strategy (West Gippsland CMA 2014).
- **Environmental objectives** which describe the asset manager and community's intended 10-year outcomes of the deployment of environmental water.
- **Targets** which are fully measurable sub-objectives that are based on measurable ecological parameters and have been made as "SMART" as possible.

Management goal

The recently completed flows study for the Thomson River (Streamology, 2020), provides a long-term vision. The vision for the Thomson River is (Figure 24): *A living river, from mountains to sea, that sustains social, cultural and ecological values, contributing to the health and prosperity of the Gippsland lakes and broader region*.

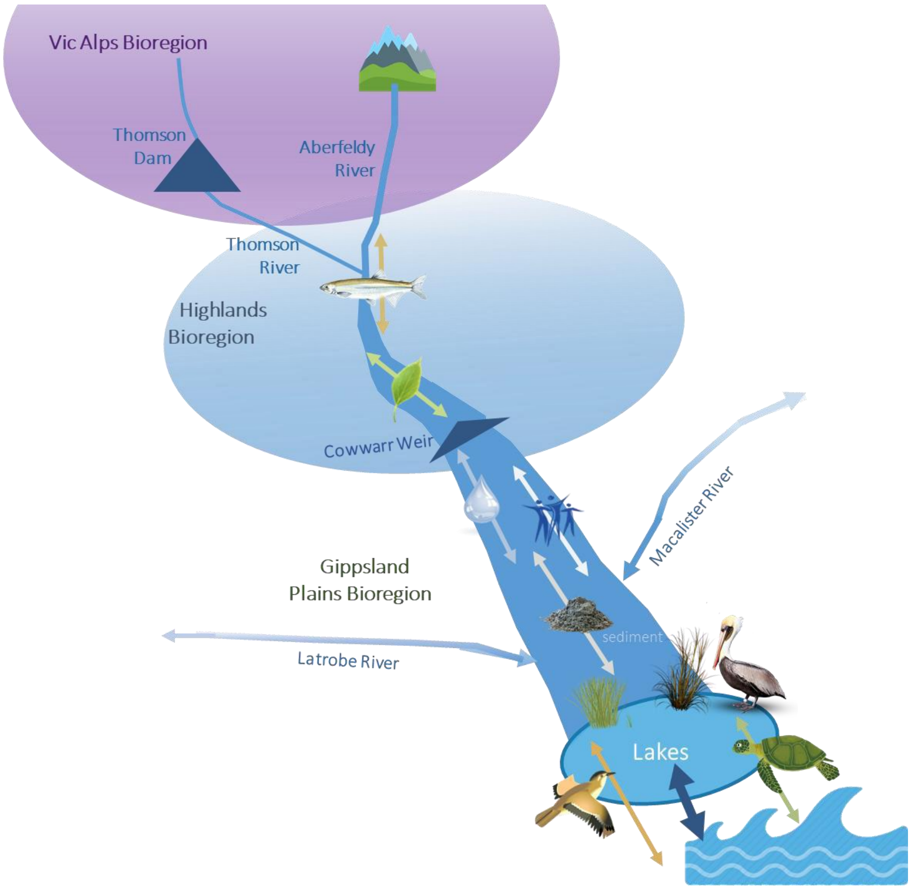


Figure 24. Conceptual illustration of the importance of lateral and longitudinal connectivity in achieving the vision for the Thomson River (Streamology 2020).

Objectives

The objectives in several relevant strategies and plans were reviewed with respect to identifying appropriate objectives for the Thomson River EWMP, and while still consistent with objectives from the West Gippsland Regional Waterway Strategy (West Gippsland CMA 2014) and Regional Catchment Strategy (WGCMA, 2022) and the Thomson and Rainbow Creek Waterway Management Plan (West Gippsland CMA 2020) the EWMP objective required a greater focus on environmental water management. The Thomson FLOW study provided 31 general objectives, which have historically been summarised or refined down to 10 in annual seasonal watering proposals, taking into consideration what is achievable within the current environmental water management arrangements. The VEWH provides a set of objectives directly related to environmental water management for the system in the annual watering plan, crafted from the annual Seasonal Watering Proposals, and these have been adopted for the Thomson River EWMP (Figure 25).

Figure 25. VEWH objectives for the Thomson River.

Targets

A review of the current state of quantitative information with respect to the values that are the target of environmental water in the Thomson River (see Water-dependent values section) and (see Trajectory of change section) informed the development SMART targets for the Thomson River.

In developing targets, the following assumptions and principles were considered:

- Targets are for the next 10 years, so recent data needs to be available (there is no use setting a target based on what the system looked like in a survey 20 years ago as there is no way of knowing if this reflects current conditions).
- Targets are a way of evaluating the effectiveness of e-water management, so should be focussed on the values for which there are management levers (e.g. excluding overbank flows) and be achievable with the existing e-water reserve and flow rules.
- Measuring against targets will take resources and so there needs to be a small number of targets that can be relatively easily assessed against to avoid wasting resources on unnecessary monitoring.
- Where relevant targets exist in other programs (e.g. regional waterway strategy, native fish report card) these will be considered to add coordination between programs and minimise duplication of effort in monitoring and reporting against targets.

There was only sufficient information to develop SMART targets for two values, fish and vegetation. The absence of targets does not mean that the other values will not be considered in this EWMP, as the plan aims to meet objectives for these values as presented in Figure 25.

Targets for Fish

The information base for native fish in the Thomson River is excellent, with a long-term data set collected through the Victorian Environmental Flows Monitoring and Assessment Program (VEFMAP) since 2005. The targets for fish have been based on this data set. Discussion with fish experts indicated that there should be targets for recruitment and abundance of target species. For fish that are stocked the target is based on presence of mature fish and juvenile fish (1+) to assess survival at multiple timeframes.

Targets for fish are:

Evidence of recruitment of the following species (2024-2034):

- Australian grayling – in at least 7 years
- Tupong – in at least 2 years
- Short-finned eels – in at least 2 years
- Long-finned eels – in at least 2 years
- River blackfish – in at least 7 years

By 2034 annual presence of Australian Bass in two life stage categories (based on Native Fish Report Card metrics):

- Mature (> 250 mm)
- Juvenile (15 – 250 mm)

By 2034, abundance of the following fish species is maintained by annual mean CPUE (fish / hour of electrofishing) as follows:

- Australian grayling > 2
- Tupong > 20
- River blackfish > 6
- Short-finned eel > 15

Continued presence of the following species in the Thomson River as evidenced by observations in at least two years from 2024 to 2034:

- Common galaxias
- Long-finned eel
- Southern pygmy perch

Targets for Vegetation

The information base for vegetation is far less robust than for native fish and is limited to a few (dated) ISC indicators and a single round of VEFMAP monitoring in one reach (reach 4) in 2019. Quantitative data are lacking for water-dependent vegetation in the other six reaches of the river below the Thomson Dam. This data deficiency strongly constrains our ability to make "SMART" targets for vegetation. Discussion with vegetation experts indicated that while we can derive targets for riparian vegetation condition as based on the most recent ISC scores, the metrics are based largely on tree condition (canopy cover, height) and this is unlikely to be influenced by environmental water. The vegetation types most affected by environmental water – in-stream vascular plants, attached algae, fringing non-woody emergent vegetation – are not well understood, in simple terms such as species composition or extent, let alone in terms of more complex matters such as trajectory of change.

Given these constraints, measurable **targets for vegetation** are as follows:

- By 2034 the Thomson River and Rainbow Creek will remain free flowing and free from encroachment of terrestrial vegetation into the riverbed.
- Average ISC streamside score to remain > 6 in all reaches downstream of Thomson Dam
- Emergent wetland vegetation communities at Heyfield Wetlands have become self-sustaining with evidence of on-going recruitment and persistence.

Two qualitative targets are also proposed, which could be strengthened if more data becomes available:

- Maintain a natural distribution of in-stream aquatic vegetation in the channel of the Thomson River consistent with longitudinal patterns in flow velocity and turbidity.
- Maintain a natural distribution of fringing non-woody vegetation (e.g., the rushes, reeds, sedges etc) that line the channel of the Thomson River, consistent with longitudinal patterns in flow velocity and habitat availability.

Environmental Water Requirements and Intended Water Regime

Flow Recommendations

The water requirements for Thomson River have been described in detail in the Thomson Flows Study, together with quantitative flow recommendations to meet those requirements (Table 10). These can be summarised in terms of the linkages with the important flow components as illustrated in Figure 26.

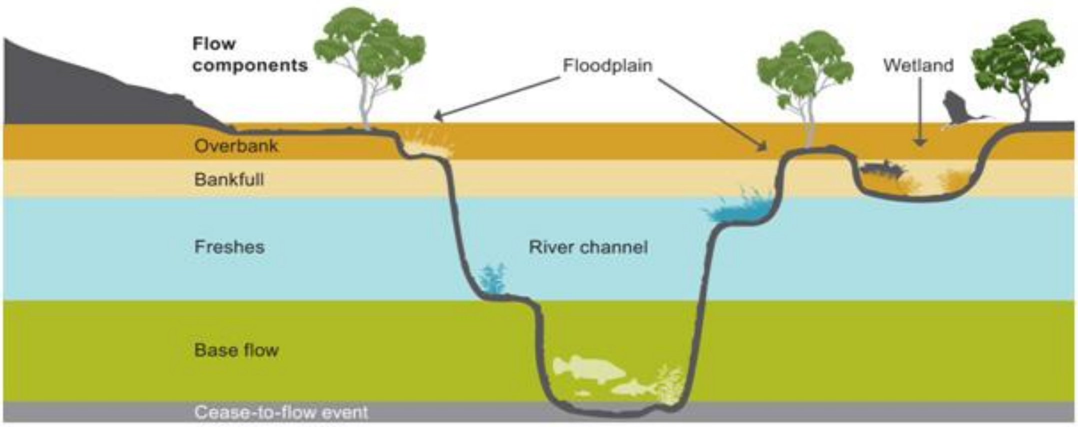


Figure 26: Flow component types and their influence on different parts of the river channel, wetlands and floodplains (Young, Bond, Gawne, & Jones, 2011).

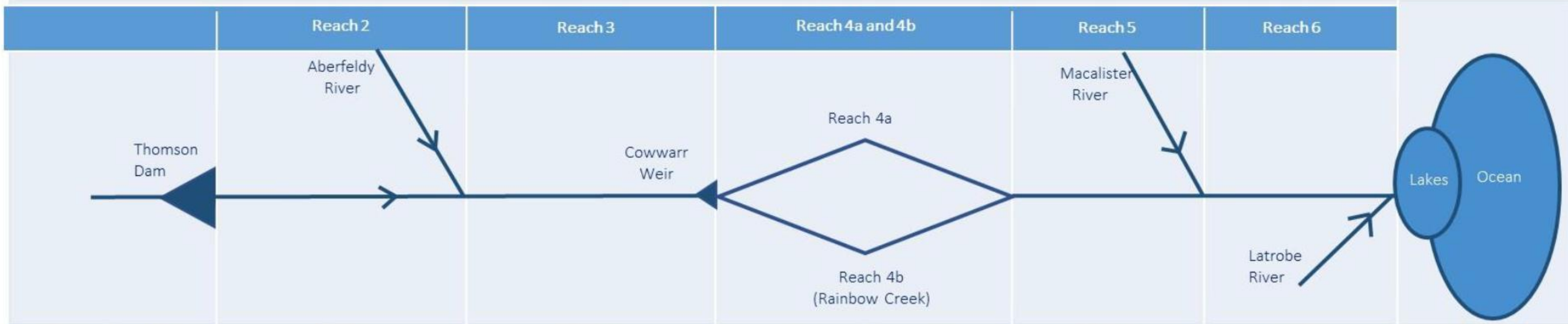
Base flows – are low flows that maintain water movement through the channel, maintaining longitudinal connectivity along the waterway and keeping in-stream habitats wet and in channel pools full. These flows occur even after prolonged periods without rain and are often due to groundwater inputs into the stream channel. These are essential for obligate aquatic species such as fish, some species of aquatic plants, and macroinvertebrates for maintaining wetted habitat and ensuring adequate water quality, particularly dissolved oxygen. They also prevent terrestrialisation of the stream bed by plants more commonly found in the riparian zone and which are intolerant of permanent inundation.

Freshes – are in channel pulses that may be short duration (days) in summer or longer (several weeks), typically in winter that exceed the median flow for the season in question. These are important for inundating in-channel benches and stimulating productivity, they act as triggers for reproductive behaviours (migration, spawning) in many native fish species and maintain water quality by flushing salts and nutrients and oxygenating the water. If adequately large they can also maintain channel form such as through scouring pools of fine-grained sediments and depositing sediments on banks and benches. If sufficiently prolonged, they can help in preventing terrestrialsation of the stream bed, by drowning-out riparian or terrestrial plants that may have colonised the stream bed during drier times.

Bankfull flows – large in-channel flows typically in late winter and spring that scour the channel, restoring geomorphic diversity and habitat. They provide water for riparian vegetation and provide nesting habitat for turtles. These flows move sediments, nutrients and salts out of the system, into downstream reaches and ultimately into the ocean.

Overbank flows – large flows, typically in late winter or early spring that spill out of the channel and inundate the floodplain. These flows are important for the movement of carbon from the floodplain to the river for maintaining productivity, for riparian and floodplain vegetation, flushing wetlands, and provision of large areas of habitat for fish, waterbirds, frogs and invertebrates. They connect the wetlands, floodplains and river systems to allow for the movement and dispersal of biota.

Table 10. Reach-based flow recommendations for the Thomson River (Streamology 2020).



Timing	Flow component	Reach 2	Reach 3	4a	4b	Reach 5	Reach 6
Summer / Autumn	Baseflow	**125 ML/d** Continuous	**125 ML/d** Continuous	**75 ML/d** Continuous	**50 ML/d** Continuous	**125 ML/d** Continuous	**125 ML/d** Continuous
	Fresh	**350 ML/d** – 1 x yr 7 days, December / Jan	**350 ML/d** – 1 x yr 7 days, Dec / Jan	**300 ML/d**– 1 x yr 7 days, Dec / Jan	**NA**	**350 ML/d** – 1 x yr 7 days, Dec / Jan	**350 ML/d** – 1 x yr 7 days, Dec / Jan
		230 ML/d – 1 x yr 7 days, Feb / March	**230 ML/d** – 1 x yr 7 days, Feb / March	**180 ML/d** - 1 x yr 7 days, Feb / Mar		**230 ML/d** – 1 x yr 7 days, Feb / March	**230 ML/d** – 1 x yr 7 days, Feb / March
		800 ML/d – 1 x yr 7 days, April	**800 ML/d** – 1 x yr 7 days, April	**750 ML/d** – 1 x yr 7 days, April		**800 ML/d** – 1 x yr 7 days, April	**800 ML/d** – 1 x yr 7 days, April
Winter / Spring	Baseflow	**230 ML/d** Continuous	**350 ML/d** Continuous	**300 ML/d** Continuous	**50 ML/d** Continuous	**350 ML/d** Continuous	**350 ML/d** Continuous
	Fresh	**800 ML/d** – 1 x yr 7 days, May	**800 ML/d** – 1 x yr 7 days, May	**750 ML/d** – 1 x yr 7 days, May	**NA**	**800 ML/d** – 1 x yr 7 days, May	**800 ML/d** – 1 x yr 7 days, May
		800 ML/d – 1 x yr 7 days, Oct / Nov	**800 ML/d** – 1 x yr 7 days, Oct / Nov	**750 ML/d** – 1 x yr 7 days, Oct / Nov		**800 ML/d** – 1 x yr 7 days, Oct / Nov	**800 ML/d** – 1 x yr 7 days, Oct / Nov
		800 ML/d – 1 x yr 7 days, Sep	**800 ML/d** – 1 x yr 7 days, Sep	**750 ML/d** – 1 x yr 7 days, Sep		**800 ML/d** – 1 x yr 7 days, Sep	**800 ML/d** – 1 x yr 7 days, Sep
	Bankfull / sub bankfull Flow	**2,000 ML/d** – every 2 yrs 1 day, anytime	**3,000 ML/d** – 1 x yr 1 day, anytime	**5,000 ML/d** – every 2 yrs, 1 day, anytime	**5,000 ML/d** – every 2 yrs, 1 day, anytime	**5,000 ML/d** – 1 x yr 1 day, anytime	**9,500 ML/d**, 1 x yr, 2 days, anytime **18,000 ML/d**, every 4th yr, 2 days, anytime

Expected Watering Effects

The expected outcomes from delivering the flow recommendations are underpinned by a series of conceptual models developed for the flows study (Figure 27 to Figure 30) and are summarised in Table 11. These represent flow volumes for Reach 3 (delivery point) and only include the flows that environmental water can be expected to contribute and so exclude overbank events. A comprehensive review of known flow-ecology relationships and the science underpinning the expected outcomes of environmental water is provided in the Issues Paper for the Thomson Flows Study (Streamology, 2020).

Table 11. Flow recommendations and associated objectives / expected outcomes (Streamology, 2020).

Flow rec	Expected outcomes
Summer / autumn baseflow (125 ML/day)	Provides adequate depth in the channel and refuge pools to provide permanent habitat and maintenance of water quality for macroinvertebrates, native fish and platypus. Provides adequate volume and depth to maintain biofilms, native submerged and emergent plants, and prevent in-stream and low-lying benches from terrestrial or weedy species colonisation.
Winter / spring baseflow (125 - 350 ML/day)	Provides adequate depth in the channel and refuge pools to provide habitat and maintain water quality for macroinvertebrates, native fish and platypus. Additionally, provides a depth of water that reduces the risk of platypus being predated upon during critical pre-breeding feeding months. Adequate volume and depth to maintain biofilms, native submerged and emergent plants, and maintains the channel by preventing in-stream and low-lying benches from terrestrial or weedy species colonisation. Increased benefits at the upper range for vegetation outcomes with respect to preventing encroachment into the channel.
Summer / autumn fresh (350 ML/day) 7 days Dec-Jan	Provides instream habitat suitable for larval/juvenile fish and macroinvertebrates. Freshening flows also provide variability to maintain and improve native vegetation, allowing opportunities for downstream dispersal of propagules and recruitment. It also provides flow variability to maintain zonation of vegetation and prevent terrestrial encroachment. Supporting the food-web via maintenance of habitat quality for macroinvertebrates.
Summer / autumn fresh (230 ML/day) 7 days Feb-Mar	As above, plus - Cue for downstream migration for adult short-finned eel, adult long-finned eel. Cue for upstream migration for juvenile short-finned eel, juvenile long-finned eel, juvenile Australian bass, juvenile common galaxias. Maintain occasional connectivity for localised fish movement between habitats for large-bodied species.
Autumn fresh (800 ML/day) 7 days in April	Cue for downstream migration for adult Australian Grayling, adult short-finned eel, adult long-finned eel, adult Australian bass, adult common galaxias. Cue for upstream migration for juvenile long-finned eel, spent adult Australian grayling.
Autumn fresh (800 ML/day) 7 days in May	Adequate volume and flow of water to maintain submerged water dependent vegetation, biofilms, and non-woody fringing vegetation. Higher flows to permit downstream dispersal of seeds and propagules of native non-woody fringing vegetation, submerged plants and other water-dependent species in the riparian zone. Flows to provide opportunities for scouring of existing biofilms and generate new colonisation sites. Mobilising fine sediments, turnover of sediment, preventing infilling of pools, and depositing sediments on existing bars and benches.
Winter / spring freshes (800 ML/day) 7 days in September and again in Oct / Nov	Providing flows that can disturb biofilms and maintain habitat quality. Providing flow variability to maintain zonation of vegetation according to elevation and flow requirements, and periodic higher flows to permit downstream dispersal of seeds and propagules. Periodic inundation of stream, low-lying benches and lower parts of the riparian zone to prevent encroachment of terrestrial weed taxa intolerant of prolonged submergence. Maintaining physical form and functioning through the turnover of sediment, mobilising fine sediment, prevention of pool infilling, and deposition of sediment on existing bars and benches.
Bankfull/Sub bankfull 3000 ML/d for 1 day (anytime)	Lateral connection with the floodplain, inundating the floodplain and low lying areas – through floodrunners that lie below the top of bank (i.e. doesn't require overbank flow). Allows mobilisation of organic and inorganic material, entrain leaf litter and dissolved organic carbon (DOC) from the riparian zone, supporting instream food webs.

Flow rec	Expected outcomes
	Maintaining adults and enhancing recruitment of juvenile water-dependent plants on the upper bank and lower floodplain (EVC 56 Floodplain Riparian Woodland). Lateral connection – supports populations of birds, reptiles and amphibians – maintains habitats and increase food sources.

Seasonally Adaptive Approach

Four climatic scenarios (as defined by the VEWH) are used to guide environmental water planning and delivery, each with their own goals:

- Drought — Protect high priority environmental assets, key functions, and priority refuges to ensure chance of future recovery and avoid catastrophic events such as low dissolved oxygen or algal blooms.
- Dry — Maintain high priority environmental assets, key functions, and priority refuges to ensure chance of future recovery and avoid catastrophic events such as low dissolved oxygen or algal blooms.
- Average — Recover by improving ecological health and resilience and enhance recruitment opportunities for key flora and fauna.
- Wet — Enhance by maximising recruitment opportunities for flora and fauna species.

Priorities for environmental watering for each climate scenario were developed using a risk-based approach with an expert panel (see Appendix 1). The approach considered what the risks were of not using environmental water to deliver each of the flow recommendations, with the highest risks representing the highest priorities for water delivery.

The outcomes of this risk assessment identified Autumn freshes as the highest priority under all flow scenarios (Table 12), but the risk of not delivering these flows was higher in average and wet years. Passing flow rules mean that low base flows (125 ML/day) are generally met under all conditions in the absence of environmental water and so these are considered lower priorities.

All of the flow recommendations are ecologically important, and priorities would change if there were multiple consecutive years in which flow recommendations were not achieved. For example, if there are multiple years where winter/spring baseflows are below 350 ML/day, there is an increased risk of the encroachment of vegetation across the bed of the river (Miller, Webb, de Little, & Stewardson, 2013). This may include the establishment of emergent macrophytes, where there is sufficient surface or subsurface water, or terrestrial vegetation in instances where the channel dries (Capon, James, & George, 2016). Once plants become established high flows are required to scour the channel, requiring much more water than that for baseflows to prevent encroachment occurring.

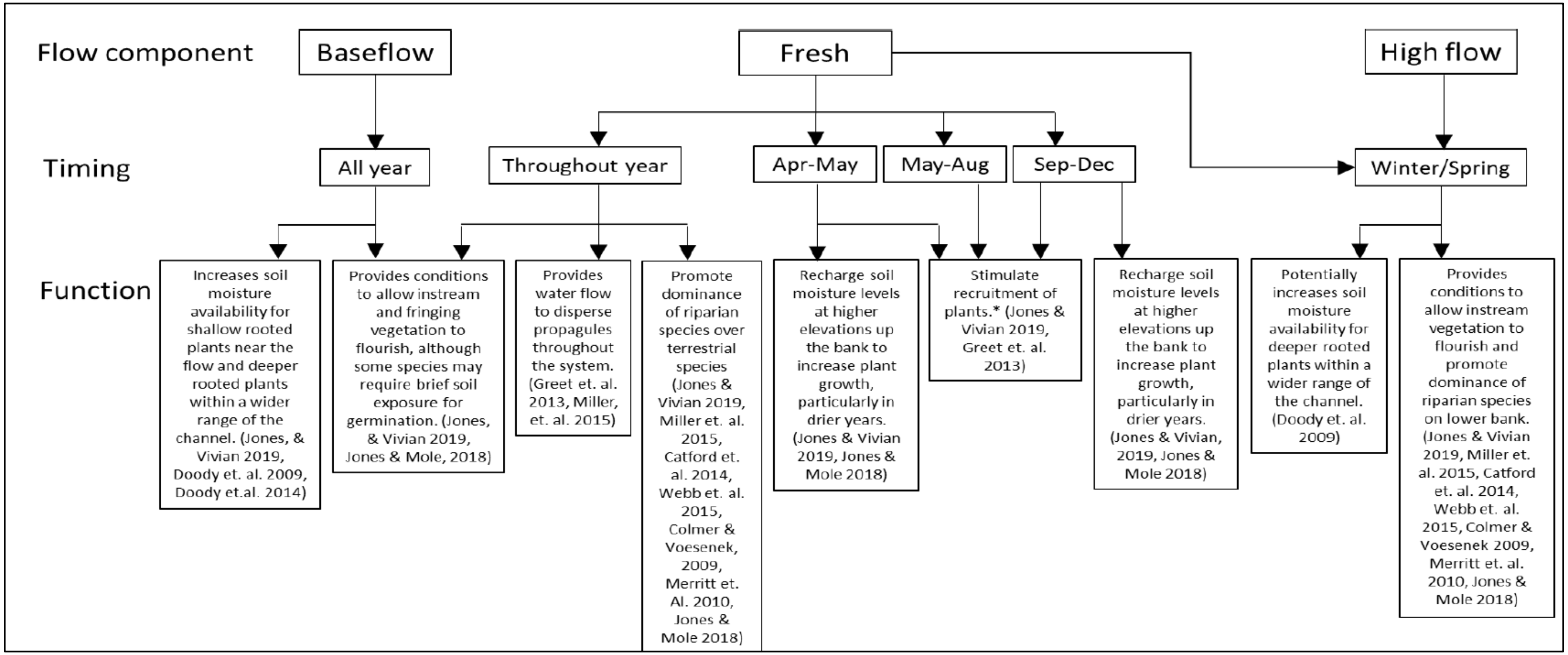


Figure 27. Conceptual model showing the flow-ecology relationships for vegetation in the Thomson River (Streamology, 2020)

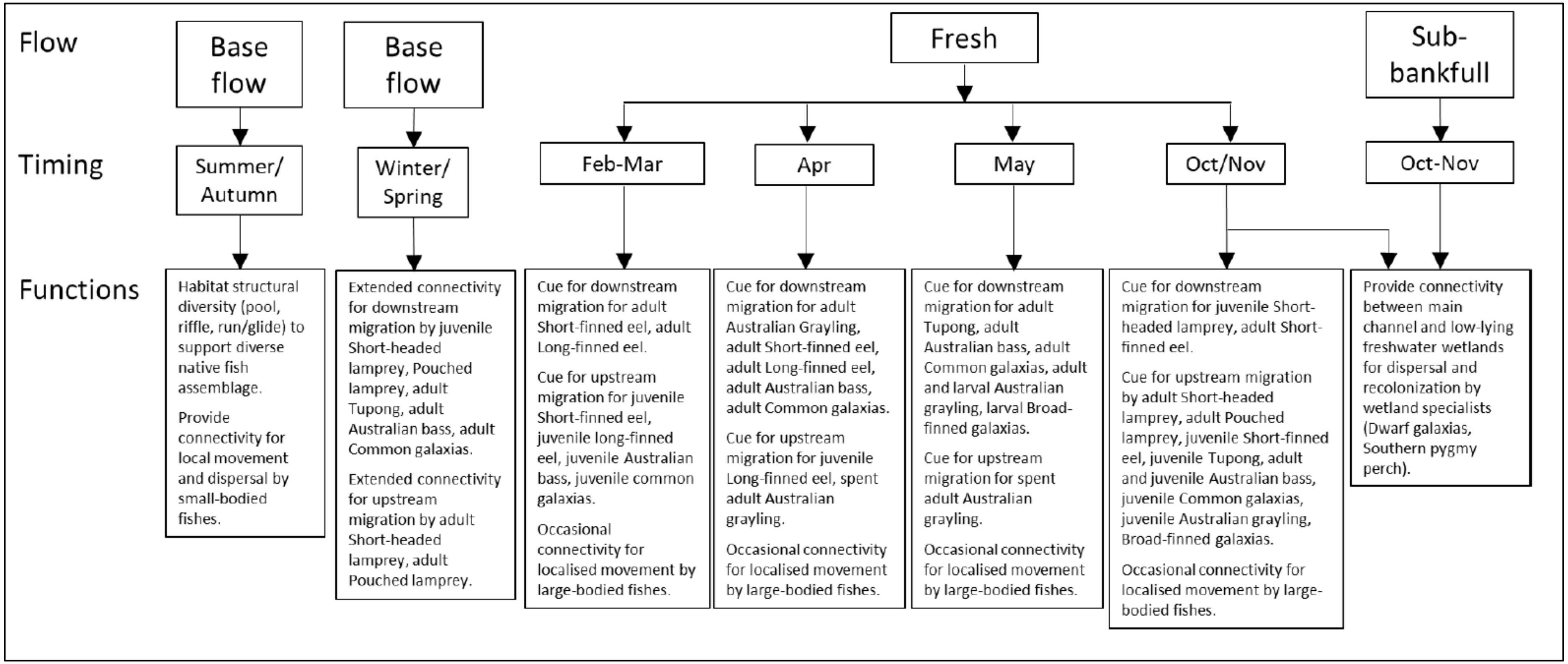


Figure 28. Conceptual model showing the flow-ecology relationships for fish in the Thomson River (Streamology, 2020).

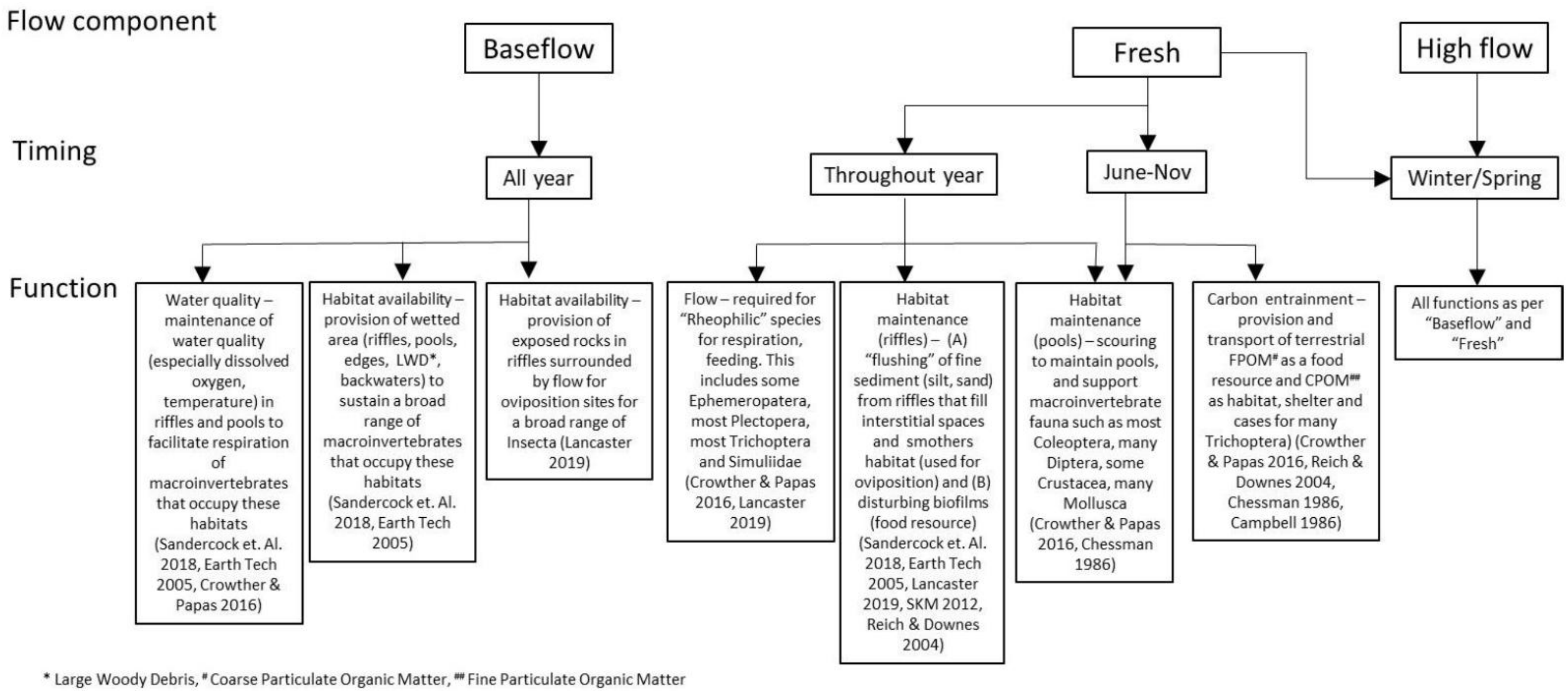


Figure 29. Conceptual model showing the flow-ecology relationships for macroinvertebrates in the Thomson River (Streamology, 2020).

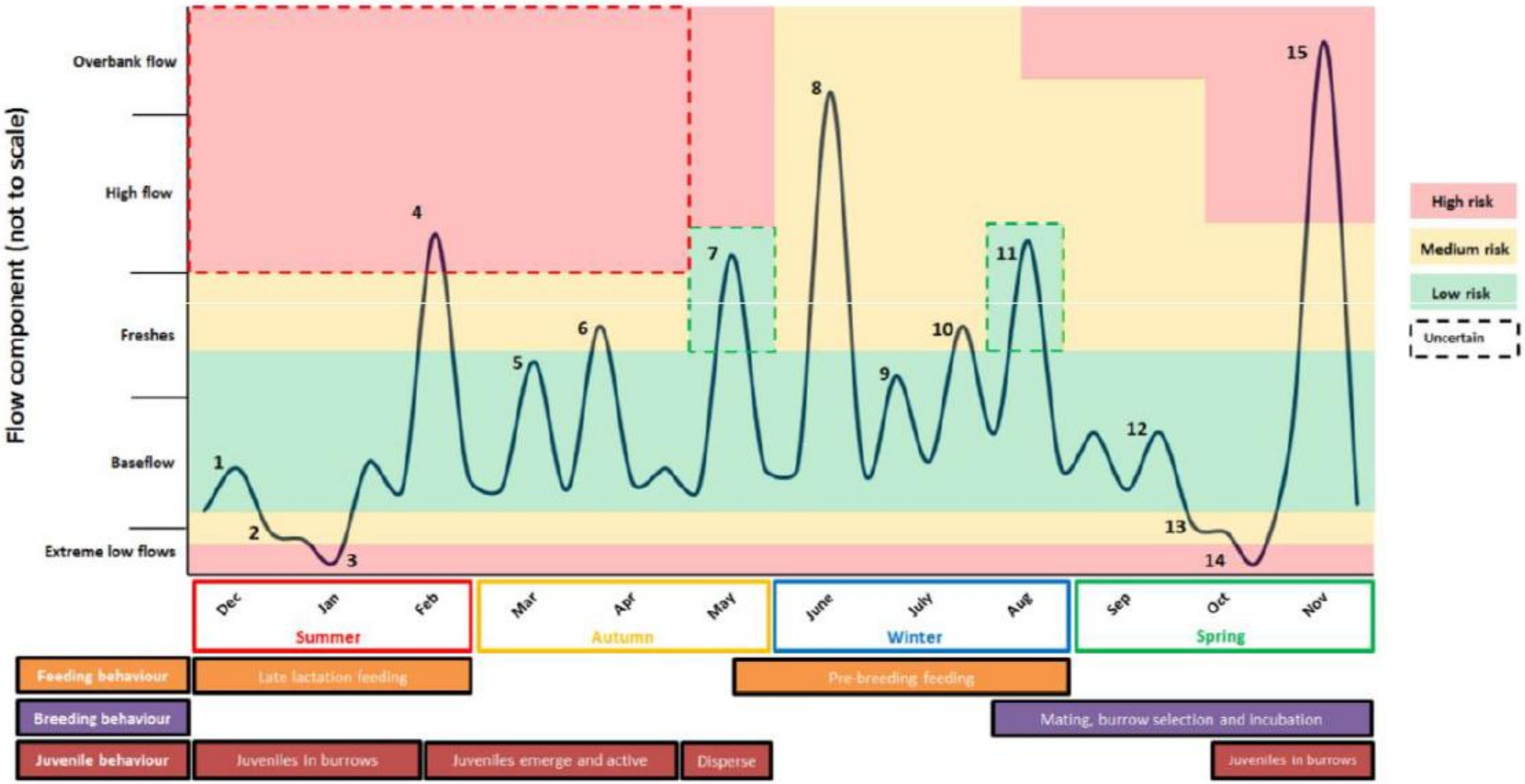


Figure 30. Conceptual model showing the flow-ecology relationships for platypus in the Thomson River (Streamology, 2020).

Table 12. Summary of risk assessment outcomes and priorities for environmental water under the four climate scenarios. Green = low risk, yellow is medium risk, orange = high risk.

Flow rec	Drought	Dry	Average	Wet	Key messages
Summer / autumn baseflow (125 ML/day)	Highest risk was "low" for low dissolved oxygen impacts on fish and decreased connectivity effecting fish dispersal				The benefits of summer/ autumn baseflows are met with passing flows and so all risks are negligible or low. If flows drop below 100 ML/day for extended periods, the risk is increased as depths are too low to support native fish and platypus.
Winter / spring baseflow (125 - 350 ML/day)	Medium (colonisation of plants in the channel)	Medium (colonisation of plants in the channel)	Medium (colonisation of plants in the channel)	Low (colonisation of plants in the channel)	The lower range of this baseflow is met with passing flows and most of the benefits are associated with the 125 ML/day flow. The exception is preventing the colonisation of terrestrial and / or emergent vegetation into the channel, for which the higher end of the flow is required. The risk in drought, dry and perhaps average years rises to "high" if there are multiple years where the flow drops low enough for plants to germinate and become established, as these will require significant flows to remove.
Summer / autumn fresh (350 ML/day) 7 days Dec-Jan	Medium (all impact pathways)	Medium (biofilms and vegetation dispersal)	Medium (biofilms and vegetation dispersal)	Medium (biofilms and vegetation dispersal)	Flow variability to maintain vegetation zonation and scour biofilms – important for food webs.
Summer / autumn fresh (230 ML/day) 7 days Dec-Jan	Medium (all impact pathways)	Medium (vegetation dispersal)	Medium (vegetation dispersal)	Negligible (all impact pathways)	Flow variability to maintain vegetation zonation and permit dispersal of propagules.
Autumn fresh (800 ML/day) 7 days in April Autumn fresh (800 ML/day) 7 days in May	Medium (all impact pathways)	Medium (vegetation dispersal)	High (diadromous fish cues, biofilms and physical form)	High (diadromous fish cues, biofilms and physical form)	This flow has other benefits, but it is about fish migration cues in general and Australian grayling specifically. You only need one of these flows and late April / early May is preferable. This flow is almost never met in any climate scenario without environmental water. Flow should be provided in every wet, average and dry year and be a priority in drought years. There is uncertainty about the flow rate required - would 600 ML / day or 700 ML/ day be enough? In unregulated rivers Australian grayling are less likely to migrate downstream to spawn during drought years and this poses a low risk if this occurs over two or three consecutive years. Consequence is higher in average and wet years, where recruitment is essential.
Winter / spring freshes (800 ML/day) 7 days in September and again in Oct / Nov	Medium (all impact pathways)	Medium (all impact pathways)	Low (all impact pathways)	Low (all impact pathways)	This flow recommendation is met in most average and wet years. As with all the flows, the risk is increased if there multiple years where the flow recommendation is not met.

Demonstrating Outcomes

Monitoring and Assessment

Priority monitoring to evaluate the effectiveness of environmental water and inform adaptive management are provided in Table 13.

Currently, the information to evaluate fish targets is provided by the VEFMAP and VEFMAP 7 has continued to 2024. Although it is not known whether VEFMAP monitoring of fish will continue to 2034, it is likely that fish monitoring in the Thomson will continue as it contributes to a long-term data set that is highly valued in assessing the effectiveness of environmental-water delivery in the river. Priority locations for fish monitoring are reaches 2 and 3 for river blackfish, reaches 3, 4a and 5 for Australian grayling and reaches 2, 3, 4a and 5 for tupong and eels. Reach 4b can be considered a lower priority location for fish monitoring if resources are limited in future years.

The vegetation condition target is based on average ISC streamside biota scores. It is not known whether this program is scheduled to continue. While the 2022 ISC assessment using LiDAR (DELWP 2022) is technically difficult and would be prohibitively expensive to replicate at a single river scale, the previous field based method (DEPI 2013) is simple and requires minimal ecological skills after the initial training has been undertaken. Other monitoring priorities, such as for terrestrial vegetation encroachment into the channel of the Thomson River channel and vegetation condition at Heyfield Wetlands, require new monitoring programs to be established. They, however, are unlikely to be complex or prohibitively expensive.

In terms of vegetation encroachment, a few easily accessible, permanent monitoring locations should be established at high-risk sites. Monitoring could be as simple as photo-points, provided that evaluation over time is assessed. Quantitative measurement would be far preferable though, and when considered within the overall total cost of the monitoring program would likely add little to the total cost when fixed costs, such as travel and reporting, were considered. Similarly, wetland vegetation monitoring for the Heyfield Wetlands could simply be to extend the photo-point monitoring initiated by the Heyfield Wetlands Committee of Management, but again with the opportunity to extend it quantitatively to fixed transects if resources allowed.

A lower priority is the measurement of dissolved oxygen at one or two priority locations. Low dissolved oxygen was identified as a medium risk associated with long periods of very low flows. Although passing flows should help to maintain water quality in pools, if periods of sustained low flows occur, it is possible that dissolved oxygen could fall to levels below which there are known impacts to native fish. Dissolved oxygen is highly variable over daily time periods. In most aquatic systems dissolved oxygen follows a daily cycle. Aquatic plants, including algae (phytoplankton) are net producers of oxygen during the day (as a by-product of photosynthesis) and consumers of oxygen during darkness (when respiratory consumption by the entire biotic community (i.e. plants plus animals plus microbes) exceeds photosynthetic production). Therefore, to truly understand the dissolved oxygen levels in an aquatic system a form of logging is required with measurements collected at no less than 15-minute intervals.

There were several themes and objectives, which can and probably are influenced by environmental water in the Thomson River, but for which there was insufficient information to develop targets (i.e.

instream vegetation, platypus, macroinvertebrates, geomorphology). Recommendations (including for monitoring) to improve our knowledge base is provided in the knowledge gaps section.

Table 13. Environmental water monitoring priorities for the Thomson River.

Theme	Indicator	Method	Location	Timing	Frequency	Links to existing monitoring
Monitoring to evaluate progress against 10-year targets						
Fish recruitment	Size structure (tail-length or fork-length)	Electrofishing as per DELWP (2017)	Reaches 2, 3, 4a, 4b, 5 and 6	February-March	Annual	VEFMAP currently conducts annual fish monitoring in the Thomson River over five days in February to March (O'Connor et al. 2022). This currently is sufficient to assess against 10-year targets for fish, if the program continues for the next 10 years.
Fish abundance / diversity	Fish presence and abundance (CPUE fish/ hour)	Electrofishing as per DELWP (2017)	Reaches 2, 3, 4a, 4b, 5 and 6	February-March	Annual	
Terrestrial vegetation encroachment	Presence / extent of terrestrial species in the channel	Photo-points	Reaches 2, 3, 4a	Autumn	Following periods of low flow	None
Vegetation condition	Canopy condition, extent and cover.	ISC Streamside vegetation (field or remote sensing methods)	Reaches 2, 3, 4a, 4b, 5 and 6	Spring	Every five years	Index of Stream Condition (most recently in 2022). It is unknown if the program will continue.
	Vegetation extent, condition and recruitment	Permanent transects or quadrats – method would need to be developed	Heyfield wetlands	Spring	Every two years	Photo-point monitoring conducted by the Heyfield Wetlands Committee of Management.
Monitoring to inform adaptive management						
Water quality	Dissolved oxygen, temperature	Continuous loggers	Reach 4	Summer-autumn	During periods of extended low flow (< 100 ML/day)	DEECA water quality monitoring network had continuous monitoring of dissolved oxygen and temperature at several sites, but they only collect flow data now.

Knowledge Gaps and Recommendations

There are several knowledge gaps relevant to the management of environmental water in the Thomson system, with respect to informing adaptive management of environmental water and evaluating the effectiveness of water management in meeting objectives. Not all are critical or should be considered a high priority. For example, the status of macroinvertebrate populations is largely unknown, but is unlikely to be a significant factor in environmental watering decisions in this system. The risk assessment was used to guide the identification of priority knowledge gaps. The following knowledge gaps and recommendations to address them are based on areas of high uncertainty and / or high risk directly related to water management in the Thomson system.

Status and Trajectory of Instream Vegetation

A significant knowledge gap is the floristic composition, extent and condition of the aquatic plants in the channel of various reaches of the river. These include the attached algal biofilms that in all likelihood fuel aquatic food webs in the river, as well as the submerged and floating-leaf vascular plants that live, rooted into the sediment, in permanent water and provide food and habitat for a wide range of aquatic organisms (see Figure 18; In-stream vegetation in the Thomson River near Cooper Creek campground. Photograph taken November 2019). These very different types of water-dependent vegetation are usually overlooked in monitoring programs (e.g. they were not considered in the ISC). They are affected strongly by baseflows (which provide the water they live in) and freshes (which scour attached algae off rocks and submerged plants, and transport propagules downstream).

In-stream vegetation is likely to change with distance downstream, being limited by fast-flowing water and availability of suitable muddy substrata upstream and by turbidity downstream. Attached algae and other biofilms, although pivotal to the food-web structure of the river, are highly variable in time and space, and thus extremely difficult and expensive to monitor. For that reason, we do not recommend the establishment of a monitoring program directed towards them.

Similarly, the emergent non-woody plants that line the fringes of the waterway stream – rushes, reeds, sedges and club-sedges – are routinely neglected in vegetation monitoring. They too are strongly affected by environmental water, with freshes controlling their vertical zonation up the riverbank. The floristic composition, extent and condition of this type of water-dependent vegetation is largely unknown for the Thomson River system. This vegetation type is likely to show rapid change over time, in response not only to the delivery of environmental water but also to alternating wet and dry climatic periods, waning and contracting during dry periods but waxing and expanding in extent during wet periods.

Attracting Flows for Upstream Movement of Diadromous Fish

While the VEFMAP program has provided a wealth of information about the effects of the hydrological regime on the movement of diadromous fish in the system (Tonkin, et al., 2020; O'Connor, et al., 2022), knowledge gaps remain.

Environmental flows have been used to improve the success of spawning migrations and spawning by Australian Grayling (Amtstaetter, O'Connor, & Pickworth, 2016). Summer and early autumn fresh releases have also increased the upstream movements of juvenile diadromous fishes such as Tupong.

There is evidence to suggest that rivers with higher discharge rates early in spring have greater young-of-year diadromous fish immigration (that is upstream from oceans to river systems). It is not clear, however, if environmental flow releases can be used to attract young-of-year diadromous fishes into the river from the ocean, particularly for rivers like the Thomson that discharge into a lake.

Answering this question for the Thomson, where there are competing rivers in the Gippsland Lakes for diadromous fish would require widening the monitoring to include other river systems such as the Tambo, Nicholson and Mitchell.

Population Status and Trajectory of Platypus

Platypus have recently been listed as vulnerable in the State of Victoria and are known to be present in all reaches of the Thomson River downstream of Cowwarr Weir (Walker & Tingley, 2023). The VEWH objective for platypus in the Thomson is "increase the abundance of platypus". There is, however, no data upon which a baseline can be established to measure an increase in numbers.

Environmental DNA (eDNA) represents a relatively inexpensive, non-invasive method for detecting species like platypus in riverine systems. Approximations of abundance can be determined and over time trajectories of change could be detected. Annual e-DNA surveys aimed specifically at platypus are recommended, with evaluation of population trends after five years.

Tailored monitoring to assess the achievement of the environmental objectives that underpin all watering actions for the Thomson River have not been undertaken, as many of these objectives are inherently difficult and expensive to measure. This is because the objective stipulates an ecological outcome that is influenced by multiple factors, other than flow alone (many of which are non-flow related).

Table 14 lists objectives that are difficult to measure and the associated knowledge gaps/potential monitoring activities associated with each objective.

Table 14 Objectives and associated knowledge gaps and monitoring activities

Objective	Can the objective be measured?	Knowledge gaps and potential monitoring activities
Monitoring of species of cultural significance	Work with GLaWAC to identify target species, locations and knowledge gaps to help inform cultural water planning and events	
Restore or maintain natural macroinvertebrate community	Difficult to measure. Macro-invertebrate communities are sensitive to multiple factors, flow being only one of these factors	Difficult to measure. Macro-invertebrate communities are sensitive to multiple factors, flow being only one of these factors

Objective	Can the objective be measured?	Knowledge gaps and potential monitoring activities
Maintain/enhance native fish community structure	This objective has been measured in part through the VEFMAP annual fish surveys and monitoring of Australian grayling spawning behaviour. However, fish communities are also influenced by a number of other factors (e.g. habitat, water quality, food availability)	Monitoring to further understand relationship between streamflow and diadromous fish recruitment (particularly for Australian grayling, tupong and Australian bass). Monitoring to better understand characteristics of flow triggers for female adult tupong (and Australian bass) spawning migration. Limited understanding of the habitat requirements, food sources and flow requirements of *all* native fish species present in the system. Limited understanding of the influence of flow on non-flow components of habitat (e.g. water quality, in-stream vegetation). Requirement for a statewide data sharing facility that is used by all CMAs and Melbourne Water so that conceptual models are shared freely and easily and new knowledge is distributed to all CMAs.
Maintain/restore distinctive riparian vegetation community and structure, with zonation up the bank	Difficult to measure. Vegetation survey data collected under VEFMAP cannot be used to assess this objective as it cannot isolate the influence of flow from other factors	Limited understanding and articulation of the water requirements of in-stream and fringing native vegetation present (that may be influenced by environmental water releases) Limited understanding on the effect of Thomson Reservoir on the distribution of seeds and propagules downstream of the reservoir Requirement for a statewide data sharing facility that is used by all CMAs and Melbourne Water so that conceptual models are shared freely and easily and new knowledge is distributed to all CMAs
Maintain channel form diversity	Difficult to measure. It is difficult to isolate the influence of flow on channel form given the land uses that predominate the catchment	Limited data on the flows required to scour substrate due to use of potentially outdated 1D hydraulic model. No data on flows required to scour biofilms. Requirement for an updated hydraulic model.

Objective	Can the objective be measured?	Knowledge gaps and potential monitoring activities
Improve water quality	This is a potentially measurable outcome. It is dependent on how influential environmental watering can be on water quality for the Thomson River, given the surrounding land use.	Limited understanding of relationship between flow and water quality variables in pools and riffles in the Thomson River. Require water quality measurements in major pools (particularly those downstream of Cowwarr Weir) before during and after the release of an event to identify the impacts of the flow release on water quality. Require water quality measurements before, during and after major unregulated flow events to elucidate the magnitude of flows required to significantly impact water quality in pools.

Environmental Water Delivery Infrastructure

Water Delivery Infrastructure

Thomson Dam and Cowwarr Weir are the main regulating structures present on the Thomson River and have been discussed in previous sections.

The following outlines infrastructure, operations and programs that also influence the ability to deliver and achieve environmental watering outcomes.

Fishways

In 1996 a rock ramp fishway was installed at the broad crested weir on Reach 4a of the Thomson River to facilitate passage of migratory fish into the upper reaches of the Thomson River through the barrier of the Cowwarr Weir. The fishway was assessed by GHD in 2006 and found to be ineffective for small-bodied fish such as the Australian grayling and Common Galaxias but effective for large bodied species. In 2011 the fishway was upgraded to include a vertical slot fish ladder Figure 31. Fish passage has not been provided at the upstream extent of Rainbow Creek at Cowwarr Weir (Streamology, 2020).

Figure 31 Cowwarr Weir rock ramp and vertical slot fishway

In 2019 a fishway was constructed at the Horseshoe Bend tunnel, located in Reach 3 of the Thomson River. This fishway connects the middle reaches of the Thomson River near Coopers Creek to upstream reaches in the Victorian Alpine bioregion, thus unlocking an additional 22 km of waterway to fish passage on the Thomson main stem, as well as access to an additional 64 km of the Aberfeldy River (WGCMA, 2020). The fishway has a minimum flow split of 60:40 between the tunnel and the fishway, respectively, to avoid compromising the heritage aspects of the diversion tunnel (Figure 32) (Streamology, 2020).

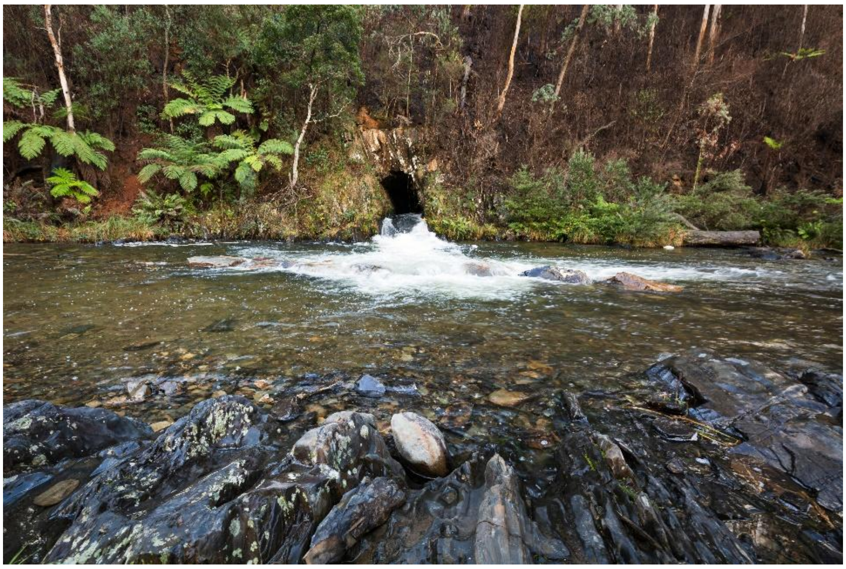


Figure 32 Horseshoe Bend Thomson River tunnel exit

Compliance Points

Operationally, environmental flows are ordered from Thomson Reservoir to meet volume targets at the Coopers Creek gauge in reach 3 (from Aberfeldy River to Cowwarr Weir) 23 kms downstream of Thomson Reservoir, as this is a compliance point for Melbourne Water. The upper section of reach 6 is also a compliance point for Southern Rural Water (SRW) and is used to assess the continuity of environmental releases down the system.

Flows at Cowwarr Weir can be split between the Thomson River (T4a) and Rainbow Creek (T4b). Unless notified otherwise, passing flows are split 2/3 in the Thomson River channel and 1/3 in Rainbow Creek. Environmental flow releases are preferentially passed through the Thomson River channel, except for autumn and spring freshes which will be split as per passing flow arrangements.

Heyfield Wetlands

Deliveries to Heyfield Wetlands are ordered to meet target volumes at the Coopers Creek gauge in reach 3, as the Melbourne Water compliance point. Water is extracted from the Thomson River via the Gippsland Water owned raw water pump station at Heyfield. Meter readings are taken at the Rose Street pump by Gippsland Water and delivered to the receiving wetlands (Figure 33) via underground pipework. Operating arrangements outlining the communication and ordering process for these deliveries is currently in draft form.

Figure 33 Heyfield Wetlands – "Donut" pond, January 2023

Irrigation Modernisation

SRW manages the Macalister Irrigation District (MID), the largest irrigation district in southern Victoria, by supplying high reliability water to dairy sector and cropping industries and vegetables. In response to growing demand for irrigation and a need to improve irrigation practices, a modernisation and expansion program known as MID2030 is currently being delivered. MID2030 includes a combination of pipelining, channel automation and regulator upgrades (SRW, 2019), all actions that will affect the volume of water available for the environment through recharge and runoff. The MID2030 program also aims to reduce farm run-off and drain outfall, which reduces nutrients being transported into the Gippsland Lakes. Although these flows are often viewed as losses from irrigation regions, they are an important source of streamflow reused downstream (Streamology, 2020).

As part of the process, SRW have undertaken mitigation water assessments and prepared Environmental Water Plans for the Thomson River, Macalister River and Sale Common. The mitigation water assessment determined that mitigation water was required to maintain environmental values in reach 5 and 6 of the Thomson River.

As mentioned earlier, following the mitigation water assessments, the VEWH are applying for an additional environmental entitlement of 1,568.8 ML of high-reliability entitlement and 691.8 ML of low-reliability entitlement held in Lake Glenmaggie, to be used by the VEWH at the mitigation water sites (Reaches 5-6 of the Thomson River and Reach 2 of the Macalister River). When in place, new operating arrangements will need to be completed between the VEWH, WGCMA, and SRW to guide the use and reporting of this entitlement.

Complementary Works

Since 2003, significant river rehabilitation works have been completed including WGCMA fencing, willow control and revegetation programs. Table 15 contains a summary of WGCMA works undertaken from 2003 - 2020 (Streamology, 2020).

Table 15: Summary of WGCMA river rehabilitation works carried out from 2003 - 2020

	Weed control works		Fencing work		Revegetation work	
River section	Total Area treated (Ha)	Length of river treated (km)	Total fence length (km)	Length of river treated (km)	Total area revegetated (Ha)	Length of river treated (km)
Aberfeldy to Cowwarr Weir (70km)	61.02	24.21	30.1	25.11	56.56	25.11
Stoney Creek to Rainbow Creek (11km)	6.01	2.52	5.17	4.27	6.02	2.82
Rainbow Ck to Macalister River (37km)	132.45	22.47	38.14	20.24	65.39	21.14
Macalister River to Park Street Sale (25km)	54.51	17.57	19.24	17.62	22.29	18.18
Sale to Latrobe River (4km)	7.42	0.8	1.85	0.8	1.11	0.8
TOTAL	261.41	67.57	94.5	68.04	151.37	68.05

A number of complementary measures are recommended to be considered for implementation in conjunction with the flow recommendations. These include:

- Consideration be given to inundating floodplain wetlands through direct pumping, if climatic considerations warrant it
- Modifying wetland connectivity in order to improve inundation frequency, particularly in order to reduce commence-to-flow levels
- Fishway maintenance at Reach 4a Cowwarr Weir and Horseshoe Bend to ensure that ecological connectivity is maintained at all times.
- Examine potential for provision of fish passage at Rainbow Creek. This is aimed to redress concerns over flows >1,000 ML/d attracting fish to migrate up Rainbow Creek
- Sediment management – Flushing from Cowwarr weir into Rainbow Creek – investigate desilt operations
- Monitor geomorphic channel changes in Reaches 4a and 4b. This would require field-based (beyond the Lidar comparison) to ensure the resolution and timescales are appropriate to assessing changes in channel bed and bank morphology.
- Fencing – Reaches 4, 5 and 6
- Control of weeds, both introduced and native 'out-of-balance' taxa – Reaches 4, 5 and 6, particularly Reaches 4a and 5
- Introduction of native vegetation through revegetation schemes – Reaches 4, 5, 6, particularly 4b (preparing Rainbow Creek)

- Carp control – Previous recommendation for drying carp eggs via water level manipulation not supported by strong field evidence. Control options such as direct removal (harvesting) and future biological controls (e.g., carp herpes virus) may be appropriate.
- Introduced brown trout are likely to have detrimental impacts on native fish in the system (especially Australian grayling and galaxiids). Engagement with the Victorian Fisheries Authority to develop trout stocking strategies that are sensitive to the requirements of native fish would limit this threat.
- Consideration be given to re-introducing large woody debris into the stream channel to provide fish habitat and hard surfaces for primary production – Reaches 5 and 6
- Monitoring for information gaps – e.g. Fish migration responses to volumes of water less than 800 ML/d.

Constraints

Not all flow components outlined in the Thomson flows study can be delivered. This may be due to current system constraints such as unacceptable impacts to downstream landholders or infrastructure related constraints. The shortfalls presented here consider both deliverable and undeliverable components.

Impacts to Landholders

Environmental water releases from the Thomson Dam are subject to maintaining the daily flow rate at the Coopers Creek gauging station below 900 ML/d to avoid flooding impacting private landholders along Reaches 4a, 4b and 5. (Note, this can be done if there is a landholder agreement in place, but it is likely this would require quite a number of agreements).

The magnitude of the Fresh flow recommendations is 800 ML/d which is under the threshold for impacting on downstream landholders, therefore the Fresh recommendations are deliverable.

Bankfull flow recommendations are classed as undeliverable as environmental flows because they range in magnitude from 2,000 ML/d in Reach 2 to 18,000 ML/d in Reach 6, well above the 900 ML/d threshold.

Infrastructure Related Constraints

Environmental releases from Thomson Reservoir are regulated through the Thomson Hydro Station and/or via two release valves located downstream of the reservoir. The design capacity of the Thomson Hydro Station is 480 ML/d at full supply capacity and the combined design capacity of the release valves is 2,300 ML/d. These capacities represent maximum rates that can be achieved when the reservoir is full, but the capacity of the release structures will reduce as the reservoir water level decreases. Environmental water releases will preferentially be made via the Thomson Hydro Station. Releases in excess of the hydro capacity will have to be made via the separate reservoir release valves.

As discussed above, Bankfull flow recommendation volumes range from 2,000 ML/d in Reach 2 to 18,000 ML/d in Reach 6. Therefore, limitations associated with the delivery infrastructure built into the Thomson Dam mean that Bankfull flows are undeliverable (with the exception of Reach 2) in addition to being above the 900 ML/d threshold.

The main constraints and issues associated with delivery of the watering actions in the Thomson River are described in Table 16.

Table 16 Constraints associated with effective environmental water delivery for the Thomson River

Constraint	Description	Implications for environmental watering
Outlet capacity sharing	• Water can be released from the Thomson reservoir to the river via the hydropower station (max. capacity of 480 ML/d) • There are also two other outlets with a combined capacity of 2,300 ML/d – however these maximums are achieved only when the reservoir is full, and capacity is lower as the water level drops	• To date the hydropower plant has been able to deliver sufficient releases for environmental and consumptive water demands • It is unlikely that outlet capacity sharing will impact on the current priority watering actions
900 ML/d volume delivery constraint	• As per the Thomson operating arrangements, to reduce the risk of flooding adjoining property, releases from Thomson Reservoir shall not exceed 900 ML/d without development of a detailed risk and flood assessment.	• This approach is not expected to impact on the ability to meet the majority of desired environmental flow regime (with most freshening flows up to a maximum of 800 ML/d). At times when releases from storage are made to meet an environmental release order immediately downstream of the Thomson Reservoir, rather than at Coopers Creek, it will be necessary to consider the potential impact of these release volumes on flooding downstream of the Aberfeldy River confluence.

Constraint	Description	Implications for environmental watering
Notification requirements	• The minimum 2 week period required for notifications to the public and storage operators, prohibits a flexible planning environment, prohibiting storage operators from being able to release environmental watering event more dynamically based on rainfall and a lull in irrigation demand (due to outlet capacity sharing constraints – see above)	• Environmental water delivery will not be able to opportunistically piggyback onto naturally occurring events • A dynamic environmental flow delivery system (using shorter notification times – or providing flexibility with delivery timing) would mean that a watering event can be timed to follow a rainfall event, and therefore potentially deliver greater ecological benefits (as the ecosystem anticipates a rise in streamflow) • In future, all partners should work together to establish a real time notification resource (e.g. a website) that consolidates planned releases – whether it be consumptive/environment. This would reduce the need for such a long notification period, and greatly reduce the effort required to notify various groups.

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Appendices

Appendix 1: Risk Assessment

1. Risk assessment method

The risk assessment process adopted for this project is consistent with the ISO 31000:2018, Risk management – Principles and guidelines and the Standards Australia Handbook: Environmental risk management - principles and process (HB 203-2000; Standards Australia and Standards New Zealand 2006).

An impact pathway approach was adopted for identifying risks. This approach uses a hierarchical process to identify potential risks as follows:

- Threats – based on the achievement of flow recommendations
- Stressors – the physical or chemical changes that could arise as a result of altered flow regimes
- Effects – the potential ecological responses caused by the stressors.

The advantage of this approach is that it provides for clear identification of the underlying causes of risks and threats to the values of the waterways, thus separating the threat from the impact. An impact pathway comprises all three levels of the hierarchy for example:

Threat	Stressor	Effect
Not achieving summer-autumn baseflows	Decreased depth and connectivity	Increased terrestrial vegetation encroachment

The impact pathways formed the basis of a formal risk analysis process. Likelihood and consequence were assigned to each impact pathway in its entirety, integrating each of the levels in the hierarchy. Likelihood and consequence descriptions used in this assessment are provided in Table 17 and Table 18 respectively and risk in Table 19. Likelihood descriptions are based on the probability thresholds developed for the Intergovernmental Panel on Climate Change (Reisinger et al. 2020) applied to the outputs of a compliance assessment completed for the Thomson River environmental flows recommendations using the Flowcaster Model compliance tool and the post-1997 step-change climate change model outputs (Streamology 2020b). Table 20 shows the full risk assessment for the drought management scenarios.

Table 17. Likelihood

Almost certain	Likely	Possible	Unlikely	Rare
Is expected to occur in most circumstances (> 90% of the time the flow recommendation will not be achieved without additional water)	Will probably occur in most circumstances (the flow recommendation will not be achieved without additional water 60-90% of the time)	Could occur (the flow recommendation will not be achieved without additional water 30-60% of the time)	Could occur but not expected (the flow recommendation will not be achieved without additional water 10 – 30% of the time)	Occurs only in exceptional circumstances (the flow recommendation will not be achieved without additional water < 10% of the time)

Table 18. Consequence

Value	Insignificant	Minor	Moderate	Major	Severe
Ecosystem function	Alteration or disturbance to ecosystem within natural variability.	Measurable changes to the ecosystem components without a major change in function.	Measurable changes to the ecosystem components without a major change in function.	Measurable changes to the ecosystem components with a major change in function.	Long term and possibly irreversible damage to one or more ecosystem function.
Habitat	Less than 1% of the area of habitat affected or removed.	1 to 5% of the area of habitat affected in a major way or removed.	5 to 30% of the area of habitat affected in a major way or removed.	30 to 90% of the area of habitat affected in a major way or removed.	Greater than 90% of the area of habitat affected in a major way or removed.
Species	No change in population size or behaviour.	Population size or behaviour may have changed but no detectable change outside natural variability.	Detectable change to population size and / or behaviour, with no effect on population viability.	Detectable change to population size and / or behaviour, with an effect on population viability.	Local extinctions are imminent / immediate or population no longer viable.

Table 19. Risk Assessment

Consequence						
		Insignificant	**Minor**	**Moderate**	**Major**	**Extreme**
Likelihood	**Almost certain**	Negligible	Medium	High	Extreme	Extreme
	Likely	Negligible	Medium	Medium	High	Extreme
	Possible	Negligible	Low	Medium	High	High
	Unlikely	Negligible	Low	Low	Medium	Medium
	Rare	Negligible	Negligible	Negligible	Low	Medium

Table 20. Risk assessment for not delivering specific flow recommendations with environmental water – Drought scenario

Threats	Stressors	Impact	Likelihood	Consequence	Risk	Evidence / comments
Not delivering Summer / autumn baseflow (125 ML/day)						**On average this flow is met with passing flows, but in some drought years flows drop below 100 ML/day. Reliability of supply is required for provision of this flow recommendation every year.**
Summer / autumn baseflow (125 ML/day)	Decreased depth	Reduces habitat for macroinvertebrates	Unlikely	Minor	Low	Low flow depths of > 0.1 m over riffles and > 0.5m in pools required for macroinvertebrates (Streamology 2020b). The hydraulic modelling from several cross-sections taken for the 2003 flows study indicate that at 125 ML/day channel depth is > 1.5 metres in Reach 3 (Earth Tech 2003). The 2020 flow recommendations were based on meeting these habitat requirements (Streamology 2020b).
Summer / autumn baseflow (125 ML/day)	Decreased depth	Reduces habitat for biofilms / algae	Unlikely	Minor	Low	Important part of the food chain, maintaining food resources during high growth periods.
Summer / autumn baseflow (125 ML/day)	Decreased depth	Impacts fish that prefer pool habitat and LWD (e.g. Australian bass)	Unlikely	Minor	Low	Depth >0.9 m, Velocity <0.5 m/sec required for Australian bass (Brown 2011). The hydraulic modelling from several cross-sections taken for the 2003 flows study indicate that at 125 ML/day channel depth is > 1.5 metres in Reach 3 (Earth Tech 2003). The 2020 flow recommendations were based on meeting these habitat requirements (Streamology 2020). If flows drop below 100 ML/day for extended then the consequence is higher.
Summer / autumn baseflow (125 ML/day)	Decreased depth	Impacts fish species with preference for run/glide habitats (e.g Australian grayling)	Unlikely	Moderate	Low	Depth 0.4-0.6 m, velocity 0.25-0.5 m/sec required for Australian grayling (Dawson and Koster 2018). The hydraulic modelling from several cross-sections taken for the 2003 flows study indicate that at 125 ML/day channel depth is > 1.5 metres in Reach 3 (Earth Tech 2003). The 2020 flow recommendations were based on meeting these habitat requirements (Streamology 2020). If flows drop below 100 ML/day for extended then the consequence is higher. Consequence is higher as threatened species.
Summer / autumn baseflow (125 ML/day)	Decreased depth	Impacts fish species with preference for riffle habitats (e.g river blackfish)	Unlikely	Minor	Low	Depth 0.1-0.2 m, velocity >0.6 m/sec required over riffles required for river blackfish (Koster and Crook 2008). The hydraulic modelling from several cross-sections taken for the 2003 flows study indicate that at 125 ML/day channel depth is > 1.5 metres in Reach 3 (Earth Tech 2003). The 2020 flow recommendations were based on meeting these habitat requirements (Streamology 2020). Cease to flow would be catastrophic.

Threats	Stressors	Impact	Likelihood	Consequence	Risk	Evidence / comments
Summer / autumn baseflow (125 ML/day)	Decreased depth and duration of inundation of stream bed	Colonisation of the streambed by terrestrial vegetation species and / or macroinvertebrates	Unlikely	Moderate	Low	The system does not cease to flow and even under drought conditions, passing flow provisions keep flows above the threshold except for isolated periods lasting only a few days. Colonisation is slow and they would be wiped out in the next winter flows or flows the year after. Higher (medium risk) if multiple years and become established. Constant water is better to stop terrestrial veg, rather than periodic high flows. Priority for higher flows before established. An ounce of prevention vs a pound of cure.
Summer / autumn baseflow (125 ML/day)	Low dissolved oxygen	Impacts native fish including the EPBC listed Australian grayling	Unlikely	Major	Medium	Despite periods of low flows below the 125 ML/day threshold during drought conditions, there is no evidence of extended periods of low dissolved oxygen in the Thomson River. Amber trigger levels as established by Cornell et al (2023) have rarely been exceeded, although records are incomplete and limited to gauging stations.
Summer / autumn baseflow (125 ML/day)	Increased temperature	Impacts native fish including the EPBC listed Australian grayling	Unlikely	Moderate	Low	Despite periods of low flows below the 125 ML/day threshold during drought conditions, there is no evidence of extended periods of high water temperatures in the Thomson River. Amber trigger levels as established by Cornell et al (2023) have rarely been exceeded, although records are incomplete and limited to gauging stations.
Summer / autumn baseflow (125 ML/day)	Decreased depth and connectivity	Impacts dispersal of diadromous fish	Unlikely	Major	Medium	
Summer / autumn baseflow (125 ML/day)	Decreased depth and connectivity	Impacts foraging and refuge habitats for platypus	Unlikely	Moderate	Low	Maintain instream habitat availability (pool depths 1 – 5m). Should the system cease to flow for extended periods, this would become a high risk.
Not delivering Winter / spring baseflow (125 ML/day)						**The lower end is always met with passing flows. 350ML / day is met on 33% of days. Risk is assessed as not meeting the 350 ML/day threshold.**
Winter / spring baseflow (125 ML/day)	Decreased depth	Reduces habitat for macroinvertebrates	Rare	Moderate	Negligible	Low flow depths of > 0.1 m over riffles and > 0.5m in pools required for macroinvertebrates (Streamology 2020). The hydraulic modelling from several cross-sections taken for the 2003 flows study indicate that at 230 ML/day channel depth is > 1.6 metres in Reach 3 (Earth Tech 2003).
Winter / spring baseflow (125 ML/day)	Decreased depth and connectivity	Impacts movement of small-bodied species	Rare	Moderate	Negligible	Base flow (areas of >0.2 m depth over riffles) required for movement of small-bodied native fish. The hydraulic modelling from several cross-sections taken for the 2003 flows study indicate that at 230 ML/day channel depth is > 1.6 metres in Reach 3 (Earth Tech 2003).

Threats	Stressors	Impact	Likelihood	Consequence	Risk	Evidence / comments
Winter / spring baseflow (125 ML/day)	Decreased depth and connectivity	Impacts movement of juvenile and adult diadromous fish	Rare	Minor	Negligible	Winter base flow (areas of >0.4 m depth over riffles) required for extended connectivity for downstream migration by juvenile Short-headed lamprey, Pouched lamprey, adult Tupong, adult Australian bass, adult Common galaxias; and for upstream migration by adult Short-headed lamprey, adult Pouched lamprey (Amtstaetter et al. 2016). The hydraulic modelling from several cross-sections taken for the 2003 flows study indicate that at 230 ML/day channel depth is > 1.6 metres in Reach 3 (Earth Tech 2003).
Winter / spring baseflow (125 ML/day)	Decreased depth and duration of inundation of stream bed	Colonisation of the streambed by terrestrial species and / or macroinvertebrates	Rare	Moderate	Negligible	The higher baseflow requirement (350ML/day) was established specifically to mitigate the risks of vegetation encroachment into the channels during extended periods of low flow (Streamology 2020).
Winter / spring baseflow (125 ML/day)	Decreased depth and connectivity	Impacts provision of refuge habitats for platypus during breeding months	Rare	Moderate	Negligible	The depth of refuge habitats for platypus in the Thomson is not defined in either flow study (Earth Tech 2003; Streamology 2020). The flows study for the Latrobe indicated a depth of at least 1m (Alluvium 2020).
Winter / spring baseflow (125 ML/day)	Low dissolved oxygen	Impacts native fish including the EPBC listed Australian grayling	Rare	Minor	Negligible	Despite periods of low flows below the 125 ML/day threshold during Drought conditions, there is no evidence of extended periods of low dissolved oxygen in the Thomson River. Amber trigger levels as established by Cornell et al (2023) have rarely been exceeded, although records are incomplete and limited to gauging stations.
Winter / spring baseflow (125 ML/day)	Increased temperature	Impacts native fish including the EPBC listed Australian grayling	Rare	Moderate	Negligible	Despite periods of low flows below the 125 ML/day threshold during Drought conditions, there is no evidence of extended periods of high water temperatures in the Thomson River. Amber trigger levels as established by Cornell et al (2023) have rarely been exceeded and never during winter / spring.
Winter / spring baseflow (125 ML/day)	Decreased depth and connectivity	Impacts dispersal of diadromous fish	Rare	Moderate	Negligible	Despite periods of low flows below the 125 ML/day threshold during Drought conditions, there is no evidence of extended periods of high water temperatures in the Thomson River. Amber trigger levels as established by Cornell et al (2023) have rarely been exceeded and never during winter / spring.
Not delivering Summer / autumn fresh (350 ML/day) 7 days Dec-Jan						**Met without e-water in 30 % of drought years. Lowest flows during Millennium Drought in summer / autumn were < 30 ML/day). This flow rec is never met in Reaches 4a and 4b**
Summer / autumn fresh (350 ML/day) 7 days Dec-Jan	Decreased scour	Impacts habitat for macroinvertebrates	Possible	Minor	Low	Freshes - flows able to scour fine sediment from rocks and to entrain leaves from sand bed areas and transfer leaves to edge of LWD habitat required for macroinvertebrates (Streamology 2020). There is not a big sediment load, Thomson Res intercepts. Exception after fire.

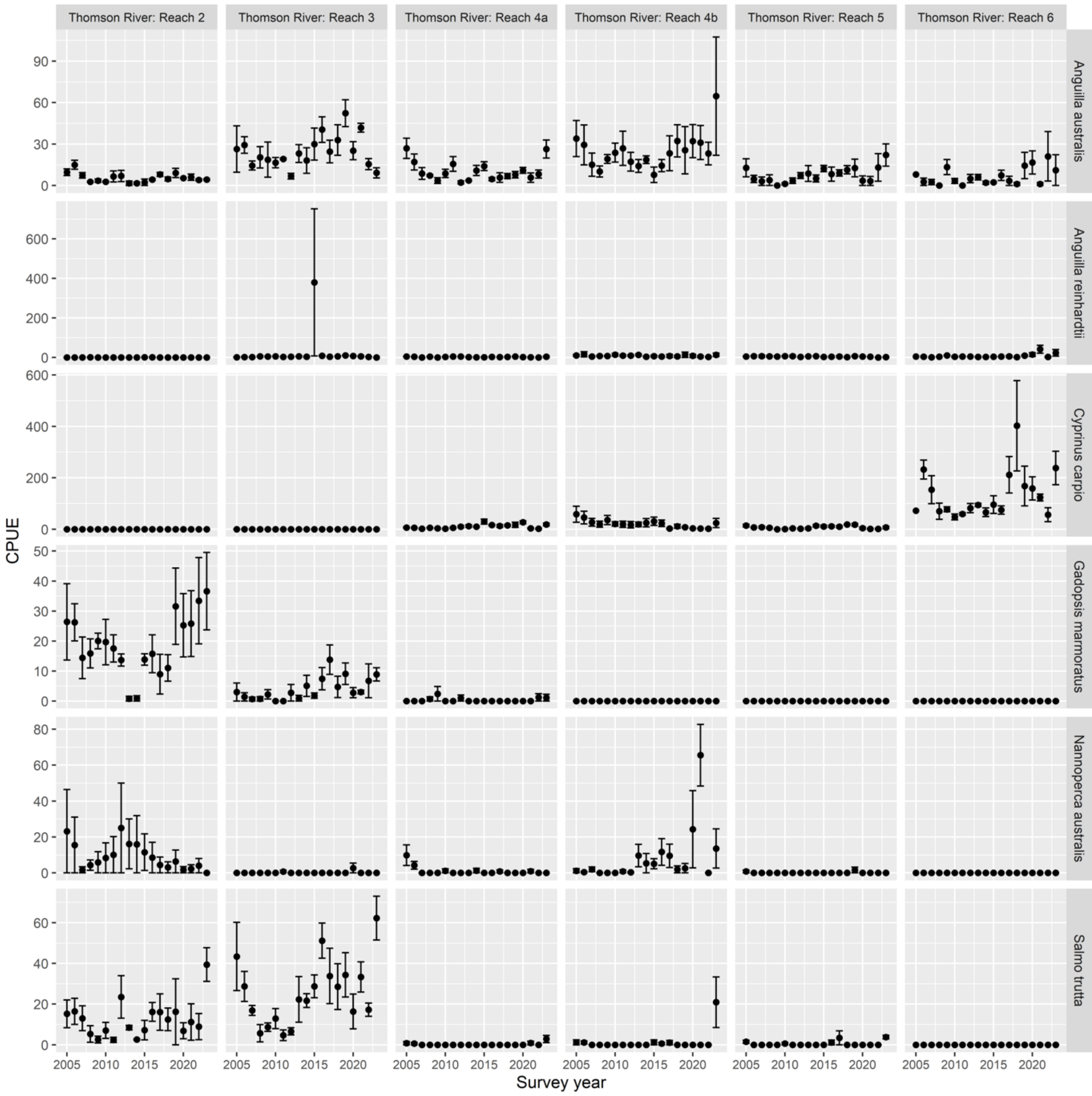
Threats	Stressors	Impact	Likelihood	Consequence	Risk	Evidence / comments
Summer / autumn fresh (350 ML/day) 7 days Dec-Jan	Decreased scour	Impacts biofilms	Possible	Moderate	Medium	Periodic higher flows to disturb substrata on which biofilms are attached, scour existing biofilms and generate new colonisation sites (Streamology 2020). Almost nothing is known of the microbial biofilms in the Thomson River, but they are likely to play an important role in food-web dynamics and nutrient spiralling in the upper reaches.
Summer / autumn fresh (350 ML/day) 7 days Dec-Jan	Increased connectivity	Impacts vegetation reproduction and recruitment	Possible	Moderate	Medium	Periodic higher flows to permit downstream dispersal of propagules and sexual and asexual recruitment. Flow variability is required to maintain zonation of vegetation
Summer / autumn fresh (350 ML/day) 7 days Dec-Jan	Decreased depth and duration of inundation of stream bed	Colonisation of the streambed by terrestrial vegetation species	Possible	Minor	Low	Freshes to prevent colonisation of low-lying benches and lower riparian zone (Streamology 2020). The duration and frequency of inundation required to prevent colonisation of aquatic habitats by native trees and shrubs is poorly understood, as is the timing and duration of inundation required to kill exotic weeds that have already colonised benches and the lower riparian zone (e.g. Blue Periwinkle Vinca major and Wandering Tradescantia Tradescantia fluminensis in Reaches 4a and 4b). Colonisation of the stream channel by undesirable native taxa under reduced flows (e.g. by Common Reed) is also possible in Reaches 3, 4a and 4b.
Summer / autumn fresh (350 ML/day) 7 days Dec-Jan	Decreased connectivity	Dispersal of fish (tupong)	Possible	Minor	Low	Depends on the size of the pulse - rate of migration decreased, but water there still move.
Not delivering Summer / autumn fresh (230 ML/day) 7 days Feb-Mar						**Met in 30 % of drought years without e-water. Lowest flows during Millennium Drought were < 30 ML/day)**
Summer / autumn fresh (230 ML/day) 7 days Feb-Mar	Decreased scour	Impacts habitat for macroinvertebrates	Possible	Minor	Low	Freshes - flows able to scour fine sediment from rocks and to entrain leaves from sand bed areas and transfer leaves to edge of LWD habitat required for macroinvertebrates (Streamology 2020).
Summer / autumn fresh (230 ML/day) 7 days Feb-Mar	Loss of flow cues	Impacts diadromous fish	Possible	Minor	Low	Fresh (areas of >0.4 m depth over riffles) as a cue for downstream migration for adult Short-finned eel, adult Long-finned eel; cue for upstream migration for juvenile Short-finned eel, juvenile long-finned eel, juvenile Australian bass, juvenile common galaxias and to maintain occasional connectivity for localised fish movement between habitats for large-bodied species. Depths of > 0.4 m are likely to still be provided by flows in the absence of environmental water. Fresh will increase dispersal, but they are still able to move at 125 ML/day. If we hit the very low flows, then the impact is higher. A few years in a row, would incresae this as a priority for downstream migration.
Summer / autumn fresh (230 ML/day) 7 days Feb-Mar	Decreased connectivity	Impacts vegetation reproduction and recruitment	Possible	Moderate	Medium	Periodic higher flows to permit downstream dispersal of propagules and sexual and asexual recruitment. Flow variability is required to maintain zonation of vegetation

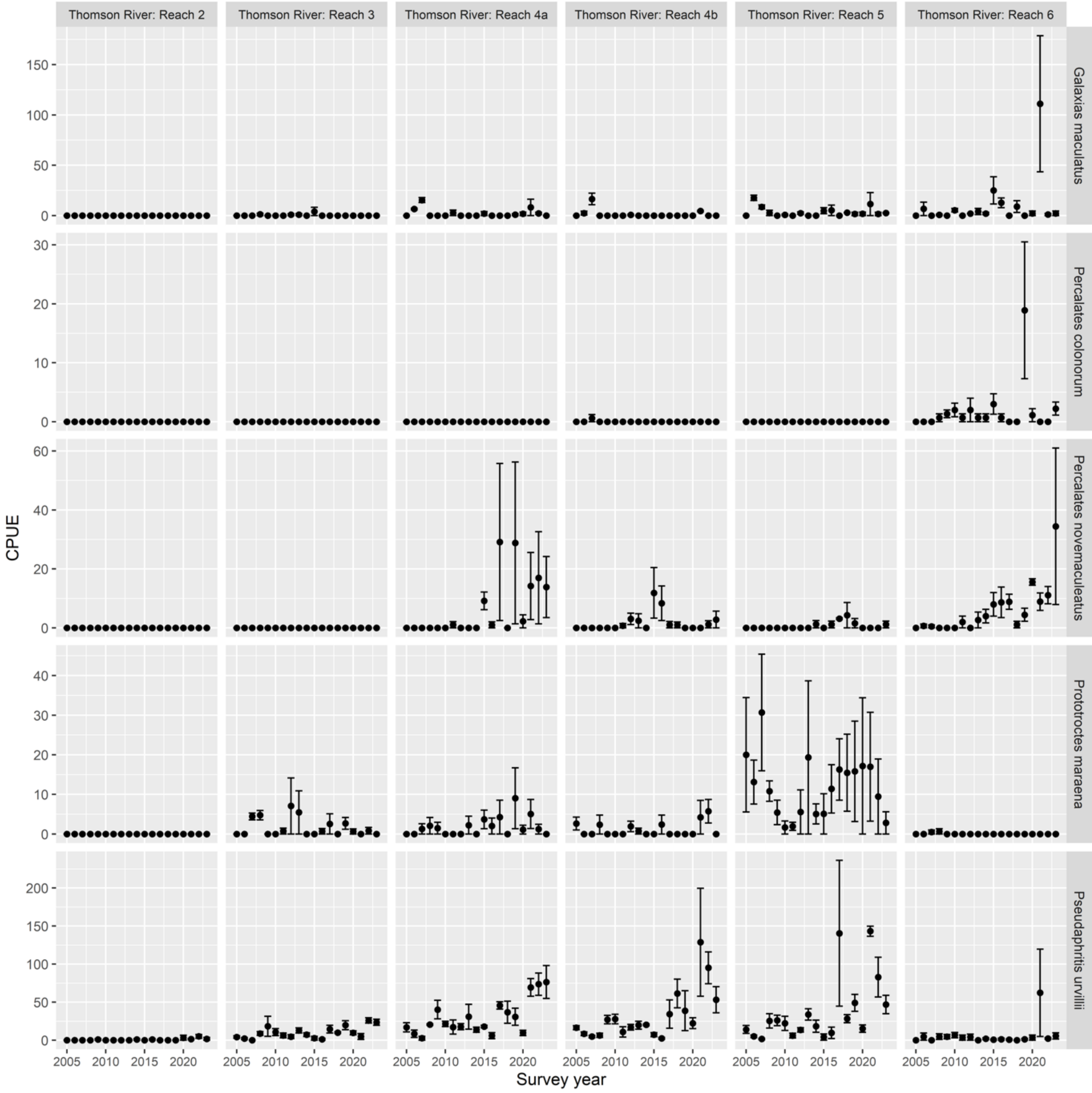
Threats	Stressors	Impact	Likelihood	Consequence	Risk	Evidence / comments
Summer / autumn fresh (230 ML/day) 7 days Feb-Mar	Decreased depth and duration of inundation of stream bed	Colonisation of the streambed by terrestrial vegetation	Possible	Minor	Low	Freshes to prevent colonisation of low-lying benches and lower riparian zone (Streamology 2020). The duration and frequency of inundation required to prevent colonisation of aquatic habitats by native trees and shrubs is poorly understood, as is the timing and duration of inundation required to kill exotic weeds that have already colonised benches and the lower riparian zone (e.g. Blue Periwinkle Vinca major and Wandering Tradescantia Tradescantia fluminensis in Reaches 4a and 4b). Colonisation of the stream channel by undesirable native taxa under reduced flows (e.g. by Common Reed) is also possible in Reaches 3, 4a and 4b. To drown terrestrial inundation requires several weeks - these freshes are not going to do much - the baseflow is more important.
Summer / autumn fresh (230 ML/day) 7 days Feb-Mar	Decreased scour	Impacts habitat for macroinvertebrates	Possible	Minor	Low	Freshes - flows able to scour fine sediment from rocks and to entrain leaves from sand bed areas and transfer leaves to edge of LWD habitat required for macroinvertebrates (Streamology 2020).
Not delivering Autumn fresh (800 ML/day) 7 days in April and 7 days in May						**Never met in its entirety. Two days over the threshold in 30% of drought years. In a drought - only aiming for one in late April - May**
Autumn fresh (800 ML/day) 7 days in April or May	Loss of flow cues	Impacts diadromous fish including the EPBC listed Australian grayling	Almost certain	Minor	Medium	April - cue for downstream migration for adult Australian Grayling, adult Short-finned eel, adult Long-finned eel, adult Australian bass, adult Common galaxias. Cue for upstream migration for juvenile Long-finned eel, spent adult Australian grayling. May - cue for downstream migration for adult Tupong, adult Australian bass, adult Common galaxias, adult and larval Australian grayling, larval Broad-finned galaxias. Cue for upstream migration for spent adult Australian grayling. Australian grayling (and several other fish species) have a short life-span (2 - 5 years). Although juveniles can colonise from other streams, a loss of several breeding seasons would have significant consequences. Flow should be provided in every wet, average and dry year and be a priority in drought years. You don't need both and you don't want the April one too early. Late April - early May is better timing. _ 7 days at the right time is enough. There is uncertainty about the flow rate required - would 600 ML / day or 700 ML/ day be enough? In a drought year, less likley to migrate and one year is okay, but two or three consecutive years becomes a higher risk. Consequence is higher in average and wet years. They can colonise from other rivers.

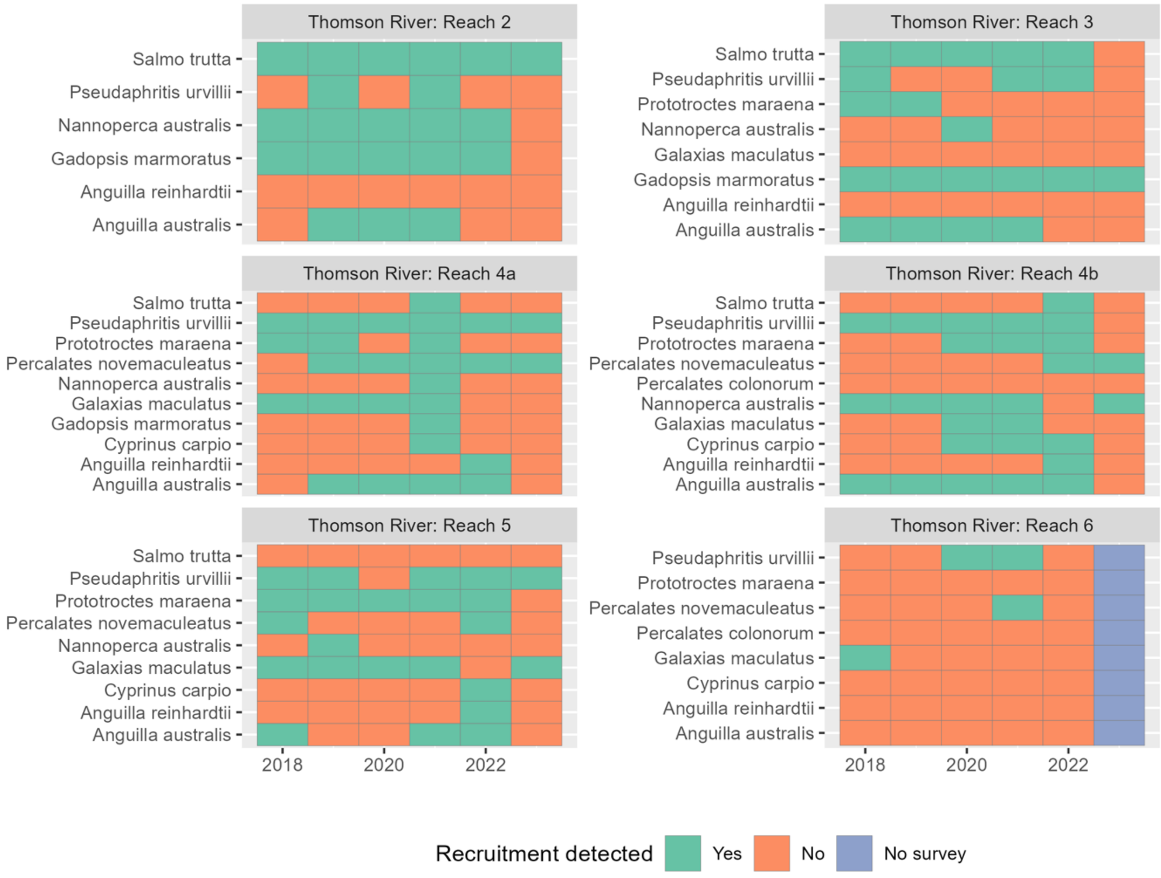
Threats	Stressors	Impact	Likelihood	Consequence	Risk	Evidence / comments
Autumn fresh (800 ML/day) 7 days in April and 7 days in May	Decreased scour	Impacts habitat for macroinvertebrates	Almost certain	Minor	Medium	Freshes - flows able to scour fine sediment from rocks and to entrain leaves from sand bed areas and transfer leaves to edge of LWD habitat required for macroinvertebrates (Streamology 2020).
Autumn fresh (800 ML/day) 7 days in April and 7 days in May	Decreased scour	Impacts biofilms	Almost certain	Moderate	High	Periodic higher flows to disturb substrata on which biofilms are attached, scour existing biofilms and generate new colonisation sites (Streamology 2020). Almost nothing is known of the microbial biofilms in the Thomson River, but they are likely to play an important role in food-web dynamics and nutrient spiralling in the upper reaches.
Autumn fresh (800 ML/day) 7 days in April and 7 days in May	Decreased connectivity	Impacts vegetation reproduction and recruitment	Almost certain	Minor	Medium	Periodic higher flows to permit downstream dispersal of propagules and sexual and asexual recruitment. Flow variability is required to maintain zonation of vegetation. Not long enough
Autumn fresh (800 ML/day) 7 days in April and 7 days in May	Decreased depth and duration of inundation of stream bed	Removal of terrestrial veg from channel	Almost certain	Minor	Medium	Freshes to prevent colonisation of low-lying benches and lower riparian zone (Streamology 2020). The duration and frequency of inundation required to prevent colonisation of aquatic habitats by native trees and shrubs is poorly understood, as is the timing and duration of inundation required to kill exotic weeds that have already colonised benches and the lower riparian zone (e.g. Blue Periwinkle Vinca major and Wandering Tradescantia Tradescantia fluminensis in Reaches 4a and 4b). Colonisation of the stream channel by undesirable native taxa under reduced flows (e.g. by Common Reed) is also possible in Reaches 3, 4a and 4b.
Autumn fresh (800 ML/day) 7 days in April and 7 days in May	Decreased disturbance	Impacts channel form	Almost certain	Moderate	High	Freshes required to maintain / enhance physical form and functioning through bed disturbance, channel maintenance refuge habitat. Would not be expected in drought years. Check with Christine
Not delivering Winter / spring freshes (800 ML/day) 7 days in September and again in Oct / Nov						**Never met. A few days over the threshold (1 – 5) in 50% of drought years.**
Winter / spring freshes (750 ML/day) 7 days in September and again in Oct / Nov	Decreased scour	Impacts habitat for macroinvertebrates	Likely	Minor	Medium	Freshes - flows able to scour fine sediment from rocks and to entrain leaves from sand bed areas and transfer leaves to edge of LWD habitat required for macroinvertebrates (Streamology 2020).

Threats	Stressors	Impact	Likelihood	Consequence	Risk	Evidence / comments
Winter / spring freshes (750 ML/day) 7 days in September and again in Oct / Nov	Decreased scour	Impacts biofilms	Likely	Moderate	Medium	Periodic higher flows to disturb substrata on which biofilms are attached, scour existing biofilms and generate new colonisation sites (Streamology 2020). Almost nothing is known of the microbial biofilms in the Thomson River, but they are likely to play an important role in food-web dynamics and nutrient spiralling in the upper reaches.
Winter / spring freshes (750 ML/day) 7 days in September and again in Oct / Nov	Increased connectivity	Impacts vegetation reproduction and recruitment	Likely	Moderate	Medium	Periodic higher flows to permit downstream dispersal of propagules and sexual and asexual recruitment. Flow variability is required to maintain zonation of vegetation
Winter / spring freshes (750 ML/day) 7 days in September and again in Oct / Nov	Decreased depth and duration of inundation of stream bed	Removal of terrestrial veg from channel	Likely	Minor	Medium	Freshes to prevent colonisation of low-lying benches and lower riparian zone (Streamology 2020). The duration and frequency of inundation required to prevent colonisation of aquatic habitats by native trees and shrubs is poorly understood, as is the timing and duration of inundation required to kill exotic weeds that have already colonised benches and the lower riparian zone (e.g. Blue Periwinkle Vinca major and Wandering Tradescantia Tradescantia fluminensis in Reaches 4a and 4b). Colonisation of the stream channel by undesirable native taxa under reduced flows (e.g. by Common Reed) is also possible in Reaches 3, 4a and 4b.

Appendix 2: VEFMAP Fish Survey Data




Thomson River: Reach 2
Thomson River: Reach 3
Thomson River: Reach 4a
Thomson River: Reach 4b
Thomson River: Reach 5
Thomson River: Reach 6
Galaxias maculatus
Percalates colonorum
Percalates novemaculeatus
Prototroctes maraena
Pseudaphritis urvillii
CPUE
Survey year
2005
2010
2015
2020



Thomson River: Reach 2
Salmo trutta
Pseudaphritis urvillii
Nannoperca australis
Gadopsis marmoratus
Anguilla reinhardtii
Anguilla australis
Thomson River: Reach 3
Salmo trutta
Pseudaphritis urvillii
Prototroctes maraena
Nannoperca australis
Galaxias maculatus
Gadopsis marmoratus
Anguilla reinhardtii
Anguilla australis
Thomson River: Reach 4a
Salmo trutta
Pseudaphritis urvillii
Prototroctes maraena
Percalates novemaculeatus
Nannoperca australis
Galaxias maculatus
Gadopsis marmoratus
Cyprinus carpio
Anguilla reinhardtii
Anguilla australis
Thomson River: Reach 4b
Salmo trutta
Pseudaphritis urvillii
Prototroctes maraena
Percalates novemaculeatus
Percalates colonorum
Nannoperca australis
Galaxias maculatus
Cyprinus carpio
Anguilla reinhardtii
Anguilla australis
Thomson River: Reach 5
Salmo trutta
Pseudaphritis urvillii
Prototroctes maraena
Percalates novemaculeatus
Nannoperca australis
Galaxias maculatus
Cyprinus carpio
Anguilla reinhardtii
Anguilla australis
Thomson River: Reach 6
Pseudaphritis urvillii
Prototroctes maraena
Percalates novemaculeatus
Percalates colonorum
Galaxias maculatus
Cyprinus carpio
Anguilla reinhardtii
Anguilla australis
2018
2020
2022
2018
2020
2022
Recruitment detected
Yes
No
No survey

Appendix 3: Thomson Risk Register

Category	Risk Description	Likelihood	Consequence	Risk	Proposed mitigation actions	Residual risk
Environment	Target flows may not be achieved if tributary inflow contributions are lower than forecast.	Possible	Minor	Low	• Experience from recent events to be reviewed to inform planning. • Rainfall and catchment responses to be closely monitored during events and adjustments made to planned releases as necessary (using data inputs from storage operators).	Low
Environment	Timing of environmental flow releases adversely impacts on Australian grayling breeding	Unlikely	Moderate	Low	• Base timing for events on monitoring data collected to date and improved knowledge from FLOWS study • Share updated information on Australian grayling behaviour with other relevant waterway managers.	Low
Reputational	Inability to demonstrate outcomes achieved through environmental watering activities lead to a loss of public/political support for activities	Possible	Moderate	Medium	• Communicate benefits of environmental watering to the broader community and government and clarify various roles in environmental watering activities. • Implement community engagement strategy to communicate local successes and benefits from environmental watering and engage the community & EWAGS in environmental water management.	Low
Environment	Current adopted environmental flow recommendations fail to achieve the intended environmental objectives	Unlikely	Major	Low	• Undertake monitoring and research to improve understanding of ecological responses and review flow recommendations if required. • Implement results of recent flow study reviews, including using findings from other systems, and undertake review of flow studies in the Latrobe and Thomson.	Low
Legal	Environmental releases cause unauthorised inundation of private land, resulting in impacts on landowner activities and assets.	Possible	Moderate	Medium	• Update and ensure currency of any applicable agreements covering inundation of private land. • Development of cautious release plans designed to avoid overbank flows. • Monitoring of events and providing feedback to the storage operator for adjustment of releases to avoid overbank flows. • Communications to alert community of environmental watering actions. • Ensure pre-order communications process in Operating Arrangements document are implemented - Use local intelligence gathering processes (works crews) to identify impacts to banks/levees following major unregulated flow events	Low

Category	Risk Description	Likelihood	Consequence	Risk	Proposed mitigation actions	Residual risk
Environment	Constraints to environmental releases such as limited river channel capacity (and risk of flooding private land) and limited discharge capacity at low storage levels constrain environmental releases, leading to a failure to achieve environmental objectives across the system - Note: Risk assessment based on environmental conditions in 2022-23. Need to review if drier conditions emerge and persist	Possible	Minor	Low	• Update and ensure currency of any applicable agreements covering inundation of private land. • Development of cautious release plans designed to avoid overbank flows. • Monitoring of events and providing feedback to the storage operator for adjustment of releases to avoid overbank flows, particularly where landholder agreements are not in place. • Development of a strategy to address environmental flow limits. Note: developing alternate release options to address constraints in the Latrobe, possibly using Moondarra & Narracan reservoirs	Low
Safety	Environmental flow releases cause a rapid change in river conditions that mean river users can quickly find themselves in conditions that are significantly different from those that they assessed before entering the water and therefore exceed their level of capability leading to potential safety risk	Possible	Extreme	High	• Include ramp-ups and ramp-down phases in release plans to reduce rapid water level changes. • Appropriate communications actions to alert users, especially for high use sites and high use periods. • Encourage river users to subscribe to website notification services of flow plans. • Implement communications plan about environmental water releases	Low
Environment	Environmental releases do not achieve planned/specified flow targets due to competing demand, outlet capacity constraints or maintenance at reservoirs or other environmental water delivery infrastructure	Possible	Minor	Low	• Scheduling of maintenance outside high demand periods (i.e. current practice). • Testing seasonal watering proposals with storage operators and owners of assets used for environmental water delivery. • Communications on planned asset outages through BE holders' forums - updating Thomson system operating arrangements document to incorporate Heyfield infrastructure operation and communications approach	Low
Environment	Environmental releases do not achieve planned/specified flow targets due to releases being diverted by other users before reaching delivery site.	Unlikely	Minor	Low	• Ensure diversions field staff are aware of planned events and are managing compliance with orders by all users. • CMA and SRW to collaborate to assess the scope of risks associated with diversion of environmental flows	Low
Reputational	Environmental deliveries affect water quality for urban purposes, leading to shortfalls in urban supply.	Unlikely	Moderate	Low	• Communication and consultation with urban water authority to understand issues and concerns, and to provide 2 weeks advance notice of flow changes where possible • Modify delivery plans to reduce potential water quality impacts where possible, particularly in peak urban demand periods.	Low

Category	Risk Description	Likelihood	Consequence	Risk	Proposed mitigation actions	Residual risk
Environment	Works on waterway structures may prevent optimal timing of environmental deliveries, resulting in environmental impacts	Possible	Minor	Low	• Consultation on any proposed works and inclusion of appropriate conditions on works approvals/licences to ensure that there are no unacceptable impacts on timing and flow rates for environmental releases.	Low
Reputational	Any public safety risks posed by consumptive water releases or natural flood events are misconstrued as environmental water releases and are detrimental to the environmental water brand.	Possible	Moderate	Medium	• Broadcast a year-round public safety message raising awareness that river levels may rise and fall quickly due to irrigation releases and environmental watering. - Notification processes for environmental water delivery clarify the role of environmental water in river operations - Environmental water engagement plan also improves understanding of environmental water actions - Undertake state-wide programs to increase environmental water understanding - Rates of rise and fall of releases managed to avoid rapid changes, except in flood emergencies when significant notification processes led by SES are undertaken. - provide updates on e-water delivery actions to SRW irrigators thru the SRW Weekly Snapshot email newsletter	Low
Environment	Insufficient water available to undertake planned environmental release actions.	Unlikely	Moderate	Low	• Undertake planning that considers the range of seasonal conditions or water availability scenarios that may unfold. • Manage carryover and consider trade as options to lessen the risks posed by supply shortfalls. • Consider options that combine environmental water with other sources (e.g. consumptive water en-route or withheld passing flows) to achieve hydrological objectives • For Thomson optimise passing flows in July/August to create water savings for use later in the season, including consideration of risk allocation for environmental and consumptive entitlement holders. (May require revision to OA document). - Not for 22-23, further analysis planned for 22-23 - residual risk based on 22-23 environmental conditions after widespread overbank flows	Low
Environment	Debris from bushfires, including ash, or erosion from drought affected areas may enter reservoirs or waterways, leading to adverse environmental impacts	Unlikely	Moderate	Low	• Monitor ash related water quality issues and adjust environmental water releases as required to mitigate impacts	Low
Safety	Environmental watering generates or spreads a BGA bloom resulting in human health risks	Unlikely	Minor	Low	- Warning signage and notifications - Consider amending delivery plans to reduce risks - Activate and participate in regional BGA coordination process	Low

Category	Risk Description	Likelihood	Consequence	Risk	Proposed mitigation actions	Residual risk
Environment	Rapid filling of Heyfield Wetlands in dry conditions may lead to slumping of wetland pond banks, impacting on environmental values of the wetlands.	Unlikely	Minor	Low	• Monitoring will be undertaken during deliveries to detect any signs of slumping and pumping rates will be reduced if necessary. • Selection of water entry point in the rocky side of the pond to further prevent slumping/erosion	Low
Service Delivery	Wet seasonal conditions cause damage to or build up of debris on infrastructure, impacting the ability to deliver environmental water.	Unlikely	Moderate	Low	Storage/Infrastrucutre manager to undertake debris clearing or conduct repairs as soon as possible and advise waterway manager of outcomes	Low