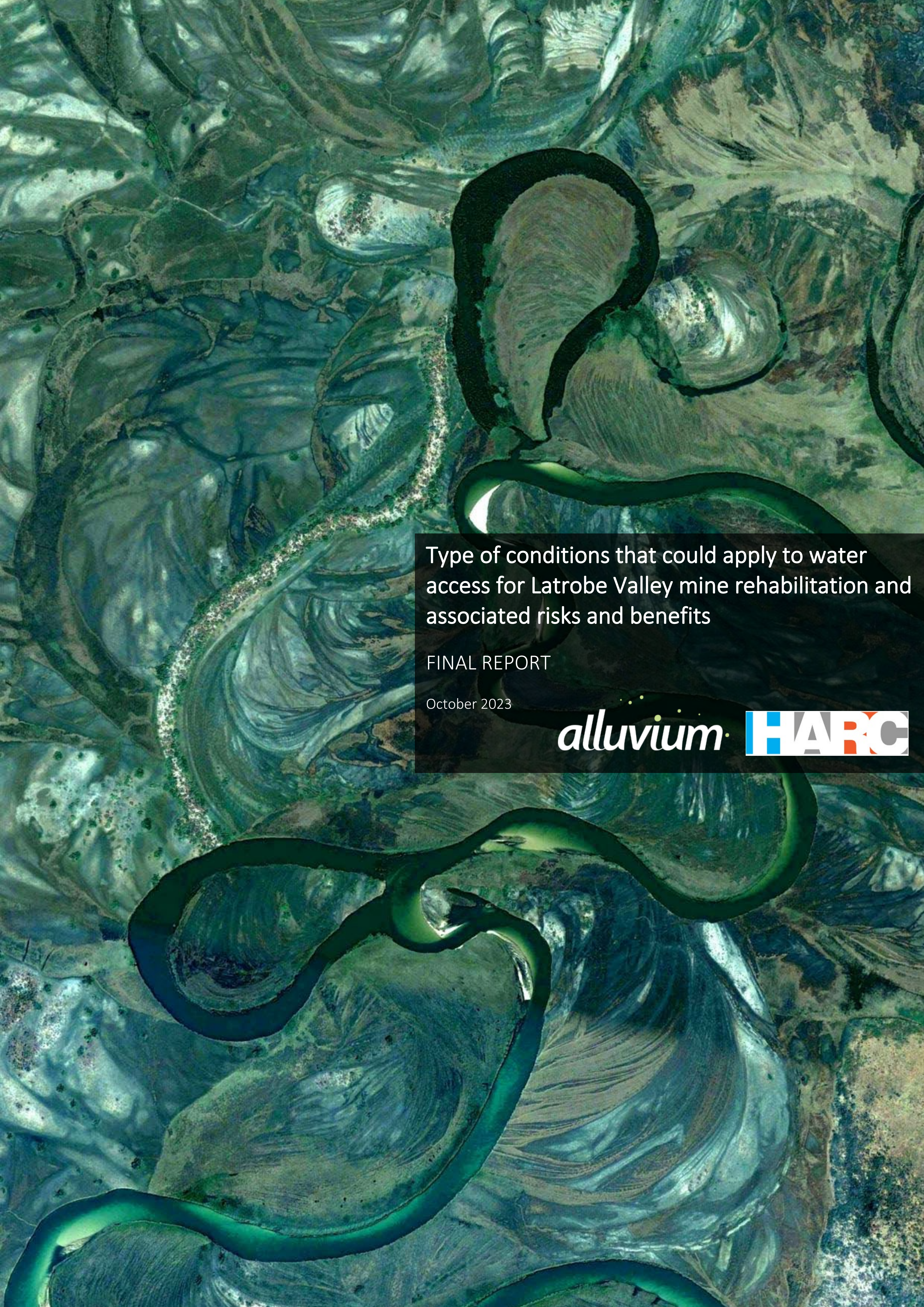

Type of conditions that could apply to water access for Latrobe Valley mine rehabilitation and associated risks and benefits

FINAL REPORT

October 2023

alluvium HARC

Alluvium recognises and acknowledges the unique relationship and deep connection to Country shared by Aboriginal and Torres Strait Islander people, as First Peoples and Traditional Owners of Australia. We pay our respects to their Cultures, Country and Elders past and present.

Artwork by Vicki Golding. This piece was commissioned by Alluvium and has told our story of water across Country, from catchment to coast, with people from all cultures learning, understanding, sharing stories, walking to and talking at the meeting places as one nation.

This report has been prepared by Alluvium Consulting Australia Pty Ltd for the Department of Energy, Environment and Climate Action under the contract titled 'Water Resource Modelling Services for potential water sources and water access arrangements for mine rehabilitation in the Latrobe Valley'

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Cover image: abstract river image, Shutterstock .

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Executive summary

This project responds to the 2020 Latrobe Valley Regional Rehabilitation Strategy (LVRRS) which includes an implementation action to provide “guidance on potential water sources and access arrangements for mine licensees to undertake rehabilitation” for which the Department of Environment, Energy and Climate Action (DEECA; formerly Department of Environment, Land, Water and Planning)[1] is responsible.

This report is a technical assessment to inform the guidance provided by DEECA as part of this implementation action by exploring the type, and impacts of, conditions that may be applied to water access for the purpose of mine rehabilitation. Importantly, this report does not allocate water in the Latrobe River system or pre-empt any future decisions by the Minister for Water. This report will form one part of the evidence base which may inform future decisions by the Victorian Government.

Approach

The transition from coal-fired power generation to mine rehabilitation requires an understanding of how water access for mine rehabilitation could impact water availability for other consumptive users, as well as Traditional Owner and environmental values. The LVRRS has been established as a guiding framework for mine rehabilitation planning. To progress guidance on how water from the Latrobe River system may be allocated and accessed for the purposes of Latrobe Valley mine rehabilitation, DEECA established a collaborative working group between DEECA representatives, Traditional Owners and stakeholders with operational responsibilities and or understanding of values in the Latrobe River system. This collaborative approach helps to ensure that any future decisions regarding access to water for mine rehabilitation takes into consideration social, economic, environmental, and cultural values.

A water resource model of the Latrobe basin (known as the Latrobe Source Model) was used for this technical assessment. The Latrobe Source Model, developed by DELWP (2021), is considered the most contemporary model for the system. It runs on a daily time step and includes the wet, average, dry and drought years that have occurred over a 63-year period of assessment. The model represents current water use and entitlements, and includes major reservoirs, farm dams, and urban, rural, power generation and environmental water use.

Reference baseline conditions in the water resource model represent the water supply system as at 2020 (for infrastructure, operating rules, and consumptive demands[2]). The model was then adapted to represent water management for mine rehabilitation under a range of potential scenarios. The baseline and all scenarios were modelled under the post-1975 historic climate reference period and projected low, medium and high climate change conditions for the year 2065.

Relevant metrics from the water resource modelling results were used to inform how changes in water availability could impact outcomes for existing water users for the water access for mine rehabilitation scenarios. Understanding the changes in risk to Traditional Owner and environmental values required the development of a robust and transparent approach specific to this project, which included an expert risk panel for the environmental values and working with the Gunaikurnai Land and Waters Aboriginal Corporation (GLaWAC) for the Traditional Owner value components of the assessment.

> **Out of scope:** This technical study does not consider options to protect Traditional Owners’ values, environmental values of the Latrobe River system or the rights of other existing water users, other than through the application of conditions on water access for mine rehabilitation.
>
> The Central and Gippsland Region Sustainable Water Strategy outlines the government's plan for managing water resources sustainably, supporting healthy waterways, climate resilient agriculture, and self-determined outcomes for Traditional Owners. This strategy is key to securing long-term water supplies, protecting jobs, farms, ecosystems, communities, and Gunaikurnai Traditional Owner cultural values. **The implementation principles of the Latrobe Valley**

[1] On 1 January 2023 under machinery of government changes, the Department of Environment, Land, Water and Planning (DELWP) Water and Catchments group became part of the Department of Energy Environment, and Climate Action (DEECA). Note that Department of Environment, Land, Water and Planning was used in the 2020 Latrobe Valley Regional Rehabilitation Strategy.

[2] Note that in some cases notional demands have been used in the modelling approach.

Regional Rehabilitation Strategy will be achieved through a combination of measures and actions, including aligning with the Central and Gippsland Region Sustainable Water Strategy, which also shapes water policies for the Latrobe Valley, aiding its socio-economic transition and preserving the uses and significance of the Latrobe River system.

Water for mine rehabilitation scenarios

Historically, water entitlements issued for power generation have been managed conservatively to protect Victoria's energy security. Based on average historical usage, the amount of water used for power generation represents only 65% of the maximum volume that could be extracted under Yallourn and Loy Yang power generator entitlements at any time. That is, historically Yallourn and Loy Yang power generators have used on average around 62.8 gigalitres (GL) compared to the full entitlement volume which is 96.5 GL. Historically, an average of around 24 GL of water per year (which must meet the required water quality standard for discharges into a waterway) has been returned to waterways downstream from the Yallourn and Loy Yang power stations and associated mines[3].

The underutilisation of power generation entitlements **has resulted in incidental benefits** for other water users and the environment, as they have been able to access some of this unused water through internal spills within storage[4], external spills from storages and generally providing greater flows in the river system, without any legal rights for other users or the environment.

The LVRRS sets out principles to guide planning for the rehabilitation of Latrobe Valley coal mines and adjacent land within a regional context (see Figure ES-1 below). The conditions on water access for the mine rehabilitation scenarios tested in this project play an important role in achieving the LVRRS implementation principles, in particular that "Any water used for mine rehabilitation should not negatively impact on Traditional Owners' values, environmental values of the Latrobe River system or the rights of other existing water users."

IMPLEMENTATION PRINCIPLES

Fire risk of rehabilitated land should be no greater than that of the surrounding environment	Traditional Owner involvement in rehabilitation planning should be developed in consultation with Gunaikurnai Land and Waters Aboriginal Corporation	Requirements for ongoing management to sustain a safe and stable landform should be minimised as far as practicable	Community should be consulted on rehabilitation proposals, the potential impacts, and have the opportunity to express their views
Mine rehabilitation should plan for a drying climate. Rehabilitation activities and final landforms should be climate resilient	Mine rehabilitation and regional land use planning should be integrated, and the rehabilitated sites should be suitable for their intended uses	Any water used for mine rehabilitation should not negatively impact on Traditional Owners' values, environmental values of the Latrobe River system or the rights of other existing water users	Ground instability and ground movement risks and impacts during rehabilitation and in the long-term should be minimised as far as practicable

Figure ES-1. Implementation principles of the LVRRS

The LVRRS also indicates that "*Any filling of the mine voids with water from the Latrobe River system would need to be subject to conditions, such as restricting or halting filling when it is dry, to prevent unacceptable impacts on*

[3] Note that water use and return flows from Hazelwood power station are not included here as they are not within the scope of this assessment.

[4] Internal spill means the redistribution of inflow which occurs when a Blue Rock Entitlement Holder's share of inflow is in excess of the volume required to fill its share of storage capacity. Internal spills can influence the amount of water available to water users in a given year, but are an incidental benefit of another entitlement holder not fully utilising their water entitlement

other water users and the environment and allow for declines in water availability to be shared between all water users."[5]

The potential conditions include mine rehabilitation at different levels of water take, with and without seasonal constraints on take to the winter-spring period, with and without constraints on lower flow harvesting of unregulated flows, and with and without limits on annual releases from Blue Rock Reservoir.

Findings and recommendations

Table ES-1 below provides a summary of the conditions tested on a hypothetical future with water access for mine rehabilitation and corresponding outcomes from the risk assessment and water resource assessment under the post-1975 historic climate reference period (represented as post 1975 – 2020). The existing risk (i.e. impact based on the modelled results) to Traditional Owner and environmental values identified in this assessment aligns with previous assessments[6] and understanding of the current system impacts on environmental and Traditional Owner values. The **current risks to environmental and Traditional Owner values under the existing baseline conditions[7] are high**. The flows under the existing baseline conditions throughout the year do not fully support fish, aquatic mammals, vegetation (wetland, riparian and floodplain) and birds in the Latrobe River, estuary and Lower Latrobe Wetlands as outlined in Environmental Water Requirements Investigation (Alluvium 2020).

The risk assessment showed that use of a maximum volume of water equivalent to the full entitlement volume held for Yallourn and Loy Yang power generation led to an increase in risk, while **maintaining water use to a maximum equivalent to net historical level of take results in no change** (i.e. no increase) in risk to environmental and Traditional Owner values. The additional conditions around restricting the take to the winter-spring period, a threshold for unregulated flow harvesting and an annual limit on Blue Rock Reservoir releases **are collectively important in reducing some risks to environmental and Traditional Owner values, noting that consistent with the baseline the overall risk rating remains high.**

The increase in risk to Traditional Owner and environmental values associated with the use of the full entitlement volume for power generation shows the incidental benefit historically experienced in the baseline where underutilisation of the entitlements by power generators resulted in increased spills from Blue Rock Reservoir, which supports winter-spring freshes, bankfull and overbank flows in the Tanjil River.

For consumptive users, under the post-1975 historic climate reference period, compared to the baseline all water access scenarios modelled led to **a decrease in reliability for rural private diverters** supplied from SRW's Latrobe River Bulk Entitlement, while there was **no impact on reliability of supply to urban water users, including industrial customers.** The most significant change was associated with use of water at a volume equivalent to the full entitlement volume, with a 12% increase in years where rural private diverters supplied from SRW's Latrobe River bulk entitlement would need to access water from the Latrobe Reserve, while other conditions resulted in 8-9% more years than in the baseline.

The loss of the incidental benefit provided by climate-resilient return flows from mine sites contributes to the decrease in reliability for rural private diverters. Even when conditions were included to limit water access for mine rehabilitation over the summer-autumn period, when irrigation demand is high, this cannot fully reduce the loss of this incidental benefit to irrigators.

In addition to the conditions on access to water for mine rehabilitation, other **complementary options to protect Traditional Owner and environmental values and irrigation reliability** could be explored. Some complementary actions have been committed to in the Central and Gippsland Region Sustainable Water Strategy (SWS), which will support irrigation users, Traditional Owner and environmental values in the Latrobe River system.

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[5] Latrobe Valley Regional Rehabilitation Strategy (DJPR 2020) page 13

[6] The current risk rating to environmental and Traditional Owners values aligns with findings from previous studies undertaken for the LVRRS (Ecological Effects Study (Hale et al. 2020) and Environmental Water Requirements Investigation (Alluvium 2020)).

[7] Reference baseline conditions represents the water supply system as at 2020 (for infrastructure, operating rules, demands) and post-1975 historic climate reference period conditions.

Projected climate change for the year 2065 could range from negligible change from historical conditions (under a low climate change projection) to significantly drier conditions (under a high climate change projection)[8]. All climate projections for the year 2065 within this range are equally plausible. Under projected low climate change scenario, conditions would be similar to those described under the post-1975 historic climate reference period. Under a projected year 2065 high climate change scenario, catchment inflows to the Latrobe River (excluding the Thomson River) would on average be 350 GL/year lower (~42% lower) than over the post-1975 historic climate reference period. There would be years of negligible access to water for mine site rehabilitation (~1 GL/year in the driest year – noting that this corresponds to a repeat of the Millennium Drought under a high climate change projection), and the volume and reliability of supply to all users would significantly decrease in the absence of other actions to enhance supply or reduce demand.

The risk assessment identified **significant increases in the risk** to environmental and Traditional Owner values of the Latrobe River system under a high climate change scenario for the year 2065. The working group acknowledged the uncertainty of a future climate and potential risks this presents to Traditional Owner and environmental values in the Latrobe River system. The group highlighted the **importance of ongoing adaptive management as part of the broader Latrobe Valley transition and adaptation to a changing climate** including monitoring of changes to water availability, assessment of the implications of these changes to Traditional Owners and environmental values and appropriate management (and possible policy) responses to best manage these changes.

[8] See Section 3 for a description of the historic climate reference period and low, medium and high climate change scenarios used in this report

Table ES-1. Summary of findings for conditions tested under the post-1975 historic climate reference period – [orange shading represents a negative change relative to the baseline, while green shading suggests positive change relative to the baseline, noting that this shading is relative to the baseline and does not represent the absolute risk rating for the scenario]

Scenario	Supply for mine rehabilitation	Impacts on consumptive users compared to the baseline scenario	Risks to Environmental and Traditional Owner values compared to the baseline scenario
Baseline consistent with average water access for power generation	No supply for mine rehabilitation. Current average annual supply for power generation: 62.8 GL/yr[9]	Rural private diverters annual reliability (based on the percentage of years over the model run in which less than 1% of the capacity of Blue Rock Reservoir is accessed from the Latrobe Reserve[10]): **98%**	The impact of the baseline (existing) conditions on environmental and Traditional Owner values in the Latrobe system is **High**[11]
		Reliability of supply to urban water users, including industrial customers: **>99%**	
Scenario 1 Water accessed for mine rehabilitation up to full entitlement volume held for power generation	Average annual supply of water for mine rehabilitation: 96.5 GL/yr	**Rural private diverters** supplied from SRW's Latrobe River bulk entitlement would need to access water from the Latrobe Reserve in **12% more years** than in the baseline	Increasing the level of take relative to the baseline, without other conditions, **materially increases the risk** to environmental values and Traditional Owner values, including through reduced critical flows during the summer-autumn period in the Latrobe River and estuary.
		Reliability of supply to urban water users, including industrial customers is unchanged.	
Scenario 2 Limit on take for mine rehabilitation equivalent to net historical water accessed for power generation – taking into account average return flows from the mine sites	Average annual supply of water for mine rehabilitation: 39.0 GL/yr	**Rural private diverters** supplied from SRW's Latrobe River bulk entitlement would need to access water from the Latrobe Reserve in **8% more years** than in the baseline	**No increased risk** relative to the baseline in the Tanjil River, Latrobe River and Latrobe estuary (and wetlands), assuming other system operations and return flows remain the same.
	Continuous supply maintained (of any volume > 1 ML/d)	Reliability of supply to urban water users, including industrial customers is unchanged.	

[9] Note that the baseline included return flows from mine sites

[10] The 2022 Central and Gippsland Region SWS recommitted to an additional 1% share of Blue Rock Reservoir being made available for irrigators. However, it is important to note that how that water is made available will be decided in consultation with stakeholders and with regard to a concurrent commitment to reallocate 16 GL from the 3-4 Bench bulk entitlement to support irrigation, environmental values and Traditional Owner self-determined outcomes. Hence, the quantification of reliability of supply used here is nominal only, reflecting a system in transition.

[11] The current risk rating to environmental and Traditional Owners values aligns with findings from previous studies undertaken for the LVRRS (Ecological Effects Study (Hale et al. 2020) and Environmental Water Requirements Investigation (Alluvium 2020)).

Scenario	Supply for mine rehabilitation	Impacts on consumptive users compared to the baseline scenario	Risks to Environmental and Traditional Owner values compared to the baseline scenario
Scenario 3 As above, with conditions that restrict access to water in winter-spring, and a threshold to prevent winter-spring baseflow from being diverted	Average annual supply of water for mine rehabilitation: 38.7 GL/yr Continuous supply maintained, but only over 180 days of the year from Jun-Nov.	**Rural private diverters** supplied from SRW's Latrobe River bulk entitlement would need to access water from the Latrobe Reserve in **9% more years** than in the baseline. Reliability of supply to other users, including urban and industrial customers is unchanged.	Conditions on the timing of take with a threshold to prevent winter-spring baseflow from being diverted **materially decreases risks** to environmental and Traditional Owner values, through protecting flows in the summer-autumn period in the Latrobe River and estuary, and winter/spring flows in the Tanjil River.
Scenario 4 As above with limits to water access from Blue Rock Reservoir	Average annual supply of water for mine rehabilitation: 37.7 GL/yr Supply reduced to 130-150 days per year over the 180-day Jun-Nov period in the driest year modelled.	**Rural private diverters** supplied from SRW's Latrobe River bulk entitlement would need to access water from the Latrobe Reserve in **8% more years** than in the baseline. Reliability of supply to urban water users, including industrial customers is unchanged.	The combination of an annual limit on Blue Rock releases with the condition to restrict take to winter-spring and a threshold to prevent winter-spring baseflow from being diverted **materially decreases risks** to environmental and Traditional Owner values.
Scenario 5 As above, but increasing the maximum water access to the volume equivalent to the gross historic volume taken during power generation.	Average annual supply of water for mine rehabilitation: 58.1 GL/yr Supply reduced to 131-145 days per year over the 180-day Jun-Nov period in the driest year modelled.	**Rural private diverters** supplied from SRW's Latrobe River bulk entitlement would need to access water from the Latrobe Reserve in **9% more years** than in the baseline. Reliability of supply to urban water users, including industrial customers is unchanged.	Taking water at gross historical take with conditions in place **materially decreases some risks and materially increases other risks** to environmental and Traditional Owner values in the **Tanjil River** relative to the baseline. It does not change the risk to environmental values in the Latrobe River and estuary relative to the baseline.

Contents

1 Introduction

Alluvium Consulting Australia Pty Ltd (Alluvium), in partnership with Hydrology and Risk Consulting (HARC), has been engaged by the Department of Energy, Environment and Climate Action (DEECA) to undertake a technical assessment to test the benefits and impacts of various scenarios for water allocation in the Latrobe River system. This project responds to the 2020 Latrobe Valley Regional Rehabilitation Strategy (LVRRS) which includes an implementation action to provide "guidance on potential water sources and access arrangements for mine licensees to undertake rehabilitation" for which the Department of Environment, Energy and Climate Action (DEECA; formerly Department of Environment, Land, Water and Planning) [12] is responsible.

The detail on the implementation action includes "to provide high-level guidance on how water from the Latrobe River system may be allocated and accessed for the purposes of Latrobe Valley mine rehabilitation including indicative conditions that may be placed on any water entitlements that protect the rights of existing users, like farmers, towns and businesses, the environment and values of Traditional Owners. This advice is to inform licensees' preparation of their Declared Mine Rehabilitation Plan."

This report is one part of the evidence base to inform the guidance provided by DEECA as part of this implementation action by exploring the type of conditions and associated risk and benefits that may be applied to water access for the purpose of mine rehabilitation to align with the following LVRRS principle: *"Any water used for mine rehabilitation should not negatively impact on Traditional Owners' values, environmental values of the Latrobe River system or the rights of other existing water users"*

Importantly, this project cannot allocate water in the Latrobe River system or pre-empt any future decisions by the Minister for Water. This report will form one part of the evidence base which may inform future decisions by the Victorian Government.

This study contemplates how water currently held and used for the purpose of coal fired power generation could be accessed for mine rehabilitation, importantly to understand how any change to access arrangements could impact:

- Traditional Owner values and environmental values of the Latrobe River system
- the water entitlements of other water users in the Latrobe River system
- how other consumptive users, the environment, and Traditional Owners access water.

This study explored the implications of possible water access conditions that could be placed on potential future water entitlements for mine rehabilitation (if needed), considering the need to minimise the impact of a drying climate on other users, environmental values, and Traditional Owners values. Specifically this study:

- Evaluates the benefits and risks of using water for mine rehabilitation on existing users, environmental and Traditional Owner values of the Latrobe River and Gippsland Lakes system.
- Technically assesses a range of measures (potential conditions) that could be applied to water access for mine rehabilitation.
- Assesses how the measures protect environmental and Traditional Owners values compared to historical use of water for power generation.
- Assesses how the measures perform under a range of climate change scenarios.

Out of scope: This technical study does not consider options to protect Traditional Owners' values, environmental values of the Latrobe River system or the rights of other existing water users, other than through the application of conditions on water access for mine rehabilitation.

[12] On 1 January 2023 under machinery of government changes, the Department of Environment, Land, Water and Planning (DELWP) Water and Catchments group became part of the Department of Energy Environment, and Climate Action (DEECA). Note that Department of Environment, Land, Water and Planning was used in the 2020 Latrobe Valley Regional Rehabilitation Strategy.

The Central and Gippsland Region SWS outlines the government's plan for managing water resources sustainably, supporting healthy waterways, climate resilient agriculture, and self-determined outcomes for Traditional Owners. This strategy is key to securing long-term water supplies, protecting jobs, farms, ecosystems, communities, and Gunaikurnai Traditional Owner cultural values. **The implementation principles of the LVRRS will be achieved through a combination of measures and actions**, including aligning with the Central and Gippsland Region SWS, which also shapes water policies for the Latrobe Valley, aiding its socio-economic transition and preserving the uses and significance of the Latrobe River system.

The scope of this project was informed by the LVRRS: Indicative Conditions Technical Working Group, a collaborative working group between DEECA representatives Traditional Owners, and stakeholders with responsibility in operation and understanding of values in the system. The project Technical Working Group includes representatives from DEECA, Gunaikurnai Land and Waters Aboriginal Corporation (GLaWAC), Southern Rural Water (SRW), and West Gippsland Catchment Management Authority (WGCMA), Gippsland Water, the Mine Land Rehabilitation Authority (MLRA) is an observer.

The overall approach to this work included identifying possible water access conditions for mine rehabilitation, representing those conditions in a water resource model, and then assessing the impacts on other users and values through relevant metrics from the model results, including a risk assessment for environmental and Traditional Owner values. This process went through iterations whereby preliminary scenarios were developed and analysed, with findings tested with the technical working group and feedback considered in the refined analysis presented in this report.

This report outlines:

- Context (Section 2)
- Water resource modelling (Section 3)
- Water for mine rehabilitation scenarios (Section 4)
- Water availability to entitlement holders (Section 5)
- Risk assessment approach (Section 6)
- Risk assessment findings (Section 7)
- Conclusion (Section 8)

Photo: Heart Morass from above, looking east, after October – November 2019 flood (supplied by WGCMA)

2 Context

2.1 The Latrobe System

The Latrobe River rises near the southern slopes of the Baw Baw plateau, part of the Great Dividing Range. Flowing to the east, south and east again, the river passes through Moe, Morwell, Traralgon, Rosedale and Sale before discharging to the Gippsland Lakes at Lake Wellington. The main tributaries of the river include Narracan Creek, the Tanjil, Morwell and Tyers Rivers and Traralgon Creek. The Latrobe regulated system includes two major storages: Blue Rock Reservoir and Moondarra Reservoir, with power generators also storing smaller volumes of water in Lake Narracan. Figure 1 provides a schematic overview of the system.

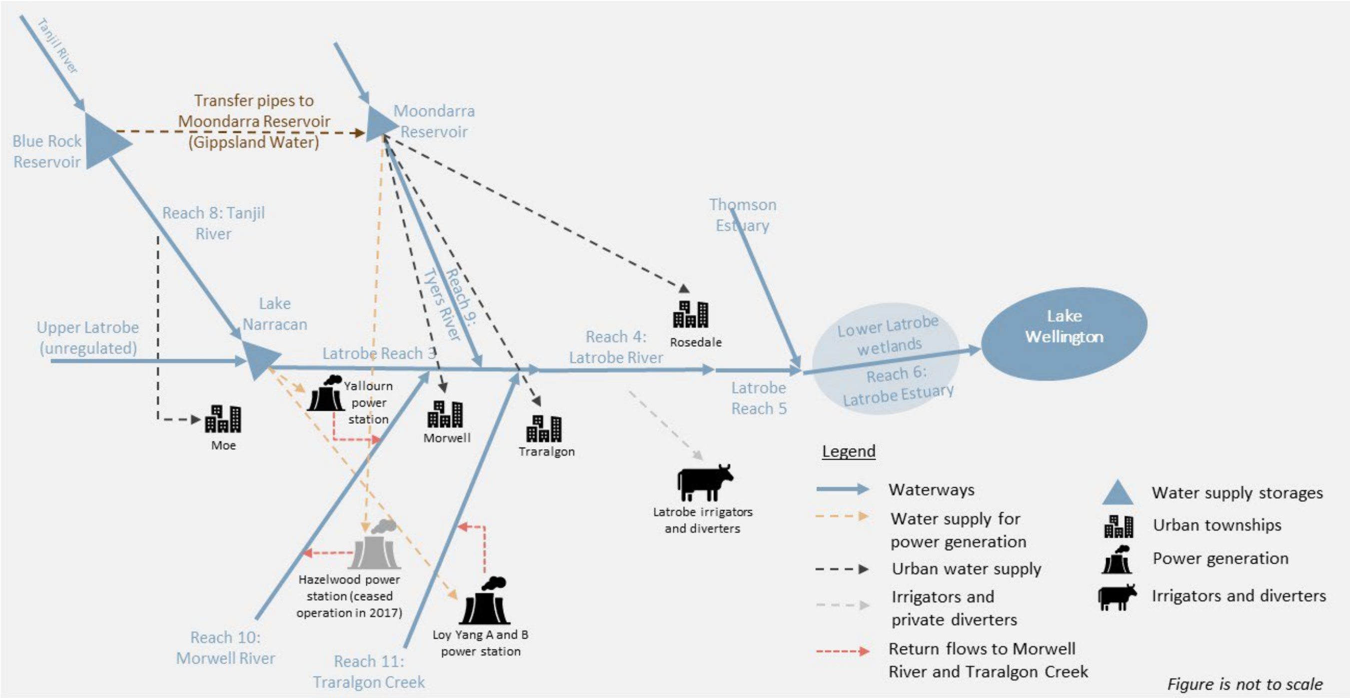


Figure 1. *The Latrobe River system overview*

For many years, power generators have and continue to be a major consumptive user in the Latrobe River System. Yallourn power station and Loy Yang A and B power stations both have bulk entitlements for power generation. The EnergyAustralia Yallourn power generator is scheduled to close in 2028, the AGL Loy Yang A power generator has a planned closure date of 2035, and the Alinta Loy Yang B power generator is set to close in 2047. ENGIE Hazelwood power station (now ceased power production) accesses water through a water supply agreement under Gippsland Water's bulk entitlement. The ENGIE Hazelwood power generator closed in 2017. ENGIE Hazelwood has a commercial agreement with Gippsland Water for access to surface water for the proposed Hazelwood Mine Rehabilitation Project which is currently subject to the outcomes from an Environment Effects Statement process.

This study contemplates the future use of water for mine rehabilitation at the Yallourn and Loy Yang sites and uses the entitlements currently held for the purpose of power generation at these sites, which include EnergyAustralia's Yallourn, AGL's Loy Yang A and Alinta's Loy Yang B power generators for comparative purposes. These power generators have the water access right to divert a combined total of up to 96.5 GL/year from the Latrobe River system, which includes defined shares of storage capacity and shares of inflow at Blue Rock Reservoir and Lake Narracan.

Historically, water entitlements issued for power generation have been managed conservatively to protect Victoria's energy security. Based on average historical usage, the amount of water utilised for power generation represents only 65% of the maximum volume that could be extracted at any time. Historically Yallourn and Loy Yang power generators have used on average around 62.8 gigalitres (GL) compared to the full entitlement volume which is 96.5 GL. An average of around 24 GL of water has historically been returned to waterways annually from the Yallourn and Loy Yang power stations and associated mines[13]. This water is required to meet necessary water quality standards.

Other consumptive water users and the environment have historically experienced incidental benefits from these return flows and underutilisation of full entitlement volume by power generators – they have been able to access some of this unused water through internal spills within storage, external spills from storages and through the occurrence of generally higher flows in the river system. Importantly, these incidental benefits to other consumptive water users and the environment do not represent a legal water access right – that is actions could be taken within the existing water access arrangements to diminish these incidental benefits such as if power generators were to draw on additional water up to their entitlement limit or if they were to halt return flows to the river (for example by recycling this water for re-use themselves).

2.2 Latrobe Valley Regional Rehabilitation Strategy

The LVRRS (DJPR 2020) is a regional-scale blueprint to guide mine licensees, government, the community and other key stakeholders on planning for and undertaking rehabilitation of the Latrobe Valley's three coal mines under a changing climate. The Strategy will guide mine rehabilitation planning for years to come and seeks to provide a pathway for DEECA to collaborate with water users and partner with Traditional Owners to ensure water used for mine rehabilitation considers the social, economic, environmental and cultural values. Importantly however, it does not prescribe the final landform for each of the mines, rather allows for the consideration of rehabilitation options that can be demonstrated to deliver a safe, stable and sustainable outcome.

The LVRRS sets out six implementation actions. These actions contribute towards achieving the LVRRS vision that the Latrobe Valley coal mines and adjacent land are transformed to safe, stable and sustainable landforms which support the next land use. Additionally, it seeks to enhance the evidence base, refine guidance, and assist mine licensees in preparing their Declared Mine Rehabilitation Plan. This report relates to the following implementation action:

> Latrobe Valley Regional Rehabilitation Strategy (Department of Jobs, Precincts and Regions 2020) implementation action: "*Guidance on potential water sources and access arrangements for mine licensees to undertake rehabilitation*"
> DELWP to provide high-level guidance on how water from the Latrobe River system may be allocated and accessed for the purposes of Latrobe Valley mine rehabilitation including indicative conditions that may be placed on any water entitlements that protect the rights of existing users, like farmers, towns and businesses, the environment and values of Traditional Owners. This advice is to inform licensees' preparation of their Declared Mine Rehabilitation Plan.

The Central and Gippsland Region SWS outlines the government's plan for managing water resources sustainably, supporting healthy waterways, climate resilient agriculture, and self-determined outcomes for Traditional Owners. This strategy is key to securing long-term water supplies, protecting jobs, farms, ecosystems, communities, and Gunaikurnai Traditional Owner cultural values. The findings of this technical report can be considered alongside broader policy including the Central and Gippsland Region SWS.

[13] Note that water use and return flows from Hazelwood power station are not included here as they are not within the scope of this assessment.

3 Water resource modelling

A water resource model of the basin (known as the Latrobe Source Model) was used for the technical assessment that have contributed to this investigation. This water resource model, developed by DELWP (2021), runs on a daily time step and includes the wet, average, dry and drought years that have occurred over a 63-year period of assessment (1957-2020). The model represents current water use and entitlements, and includes major reservoirs, farm dams, and urban, rural, power generation and environmental water use.

Reference baseline conditions in the water resource model represent the water supply system as at 2020 (for infrastructure, operating rules, demands). The model was then adapted to represent water management for mine rehabilitation under a range of potential operating conditions.

The assumptions within the model and in developing the scenarios have been developed in conjunction with the project Technical Working Group. Their development was informed by some initial water resource modelling results.

The baseline and all scenarios were modelled over the post-1975 historic climate reference period. The rationale for selecting the post-1975 historic climate reference period for use in this assessment is consistent with the *Guidelines for Assessing the Impact of Climate Change on Water Availability in Victoria* (DELWP, 2020) and includes:

- It incorporates a wide range of natural climate variability, including the Millennium Drought, the 1982–83 drought and several relatively wet years.
- It is long enough to reasonably apply data extension techniques, such as historical data scaling or stochastic data generation, that can incorporate greater natural climate variability.
- It aligns with the reference periods adopted by CSIRO when estimating the projected changes in temperature, rainfall, potential evaporation and runoff from global climate models.
- The start date is broadly consistent with observed step changes in climate behaviour.

To project possible future impacts of climate change on rainfall, evaporation and runoff, modelling was done in accordance with the *Guidelines for Assessing the Impact of Climate Change on Water Availability in Victoria* (DELWP, 2020). These were for the low, medium and high climate change scenarios (representing the 10^{th}, 50^{th} and 90^{th} percentile outcomes from 42 different global climate models) under the RCP8.5 emissions scenario, which is a suitably precautionary scenario for water resources planning. The adjustments to the post-1975 historic climate reference period climate and streamflow data included:

- For year 2065 high climate change conditions, a 41.5% reduction in runoff, an 16.7% reduction in rainfall, and an 11.3% increase in potential evapotranspiration.
- For year 2065 medium climate change conditions, a 16.3% reduction in runoff, a 4.5% reduction in rainfall, and a 7.6% increase in potential evapotranspiration.
- For year 2065 low climate change conditions, a 0.1% increase in runoff, a 2.2% increase in rainfall, and a 4.8% increase in potential evapotranspiration.

All of these climate change projections are considered equally plausible and therefore none of these climate change scenarios can be considered more or less likely than the others.

Urban and rural demands, and return flows generated by wastewater treatment plants, industrial and power generation use, were simplistically assumed to remain unchanged under projected climate change. In practice, demands could be expected to increase under hotter and drier climate conditions, with a corresponding increase (or decrease) in wastewater treatment plant return flows, depending on whether water availability becomes a limiting factor for supply. Likely changes in industrial return flows under hotter and drier climate conditions are unknown.

Note that changes in frequency and intensity of extreme events due to climate change, such as flooding is not directly assessed in this study.

The baseline and all scenarios were modelled under projected low, medium and high climate change for the year 2065. The 2065 low climate change scenario is similar to the post-1975 historic climate reference period scenario, except for higher net evaporation from reservoirs. Net evaporation from reservoirs represents a comparatively small component of the overall basin water balance.

This report therefore focuses on the post-1975 historic climate reference period and the 2065 high climate change scenario as these two climate scenarios reasonably generate the range of climate change projections recommended in the DELWP (2020) climate change guidelines.

4 Water for mine rehabilitation scenarios

4.1 Conditions to be tested

The following conditions have been developed to align with the LVRRS implementation principles, including that "Any water used for mine rehabilitation should not negatively impact on Traditional Owners' values, environmental values of the Latrobe River system or the rights of other existing water users."

The LVRRS also indicates that "*Any filling of the mine voids with water from the Latrobe River system would need to be subject to conditions, such as restricting or halting filling when it is dry, to prevent unacceptable impacts on other water users and the environment and allow for declines in water availability to be shared between all water users.*"[14]

Introducing conditions on water access for mine rehabilitation linked to climate conditions could help to mitigate potential adverse impacts on security of supply of existing entitlements and impacts on Traditional Owner and environmental values, taking into account the variability of flows in the Latrobe system. This variability can be considered in terms of drier and wetter seasons of the year and in terms of drier and wetter years, including droughts and flood years. For the Latrobe system, the variability within a year includes typically drier months in summer and autumn while winter and spring are typically wetter (Alluvium 2020).

Condition A - Maximum annual volume for mine rehabilitation

The entitlements for power generation allow for up to a total maximum volume of 96.5 GL/year to be taken across the Yallourn, Loy Yang A and Loy Yang B power stations. This is referred to as the full entitlement volume. Power generators historically have not fully utilised their water entitlements. The bulk entitlements issued for power generation have been managed conservatively to protect energy security, such that the volume taken annually is typically far below the maximum cap on take.

Gross historical take is representative of the level of water that has been used for power generation over the long term. Net historical take is gross historical take less return flows to the Latrobe River system from the power generators and mines. The volumes returned to the river system from power generation have provided an incidental benefit to irrigators and the Environmental Water Reserve.

A range of annual volume conditions are assessed in this report to provide a mix of scenarios at full uptake of power generator entitlements, and at lower levels of demand for mine rehabilitation that are more consistent with the conditions under which current environmental values have been established. This range of volumes for mine rehabilitation include (with volumes presented in Table 1):

- Up to full entitlement volume held for power generation
- Equivalent to gross historical take water accessed for power generation
- Equivalent to net historical water accessed for power generation – taking into account average return flows from the mine sites

Table 1. Annual diversion limits assumed in the technical assessment

Maximum volume of water available (GL/year)	Full uptake of bulk entitlement	Gross historical use	Return flows	Net historical use
Yallourn	36.5	27.0	16.6	10.4
Loy Yang A	40.0	21.1	3.6	17.5
Loy Yang B	20.0	14.7	3.6	11.1
Sub-total Loy Yang	*60.0*	*35.8*	7.2	*28.6*
Total	**96.5**	**62.8**	**23.8**	**39.0**

[14] Latrobe Valley Regional Rehabilitation Strategy page 13

Note that while in practice, supply from the existing Loy Yang A and Loy Yang B bulk entitlements for power generation could be managed collectively for future mine rehabilitation, within the constraints of each entitlement, they are reported on separately in this assessment for comparative purposes to reflect the current entitlement framework and water resource model configuration.

Condition B - Restricting take to the wettest months of the year (1 June-30 November)
The winter-spring months of June to November inclusive are typically the months of highest inflow into the Latrobe River system. The restricting of take for mine rehabilitation to the wettest months of the year avoids the summer-autumn take when river is most flow stressed, and irrigator demand for unregulated flows is highest.

From an environmental water management perspective, protecting and restoring summer-autumn freshes and baseflows in the Latrobe River below Lake Narracan are the highest priority to:

- Maintain water quality and increase habitat
- Support drought refuges
- Prevent critical loss of species.

The priority flow components identified as part of the Latrobe Environmental Water Requirements Investigation are shown below (Table 2). This is also reflected in the environmental water recovery targets in the 2022 Central and Gippsland Region SWS, which prioritise recovery of water for summer-autumn flows in the Latrobe River. It is important to note that any environmental water recovery would be complementary and in addition to the possible water access conditions on take of water for mine rehabilitation to achieve better summer-autumn environmental flows.

Further information on the flow components is provided in Section 6 and Appendix A5.

Table 2. Priority flow components for the Latrobe system (Alluvium 2021)

<table>
<tr><th rowspan="2">Location (see Figure 1)</th><th colspan="4">Priorities</th></tr>
<tr><th>1 (high priority)</th><th>2 (high & second priority)</th><th>3 (potentially deliverable, i.e. once constraints are addressed)</th><th>4 (all)</th></tr>
<tr><td>Reach 3 & 4</td><td colspan="2">Summer-autumn fresh 1&2
Summer-autumn baseflows</td><td>Summer-autumn fresh 1&2
Summer-autumn baseflows
Winter-spring baseflows
Winter-spring fresh</td><td>All flow components</td></tr>
<tr><td>Reach 5</td><td>Summer-autumn fresh 1&2
Summer-autumn baseflows</td><td>Summer-autumn fresh 1&2
Summer-autumn baseflows
Winter-spring baseflows</td><td>Summer-autumn fresh 1&2
Summer-autumn baseflows
Winter-spring baseflows
Winter-spring fresh</td><td>All flow components</td></tr>
<tr><td>Estuary</td><td>Summer-autumn fresh 1</td><td>Summer-autumn fresh 1&2
Summer-autumn baseflows</td><td>Summer-autumn fresh 1&2
Summer-autumn baseflows
Winter-spring Fresh 1</td><td>All flow components</td></tr>
</table>

Condition B that restricts take to the wettest months of the year also protects the Tanjil River from unnaturally high flows due to releases from Blue Rock Reservoir to supply demands during the summer-autumn period. A preliminary model scenario showed that where this condition is not adopted, there can be higher flow releases in the Tanjil River that can impact the environmental values.

Note that the under Condition B (i.e. for scenarios 3-5), the mine rehabilitation demand is modelled as a static demand over the winter-spring period. When Condition B is not in place (i.e. for scenarios 1 and 2), the mine rehabilitation demand is modelled as per the baseline power generation demand, with a peak in summer.

Condition C - A threshold to prevent winter-spring baseflow from being diverted
The aim of this condition is to protect winter/spring low flows of ecological importance, and of importance for Traditional Owners. Under this condition, harvesting of unregulated flows for mine rehabilitation only occurs when flows are high at Willow Grove (Latrobe River), above 447 ML/d. This 'threshold to prevent winter-spring baseflow from being diverted' was set as the median winter/spring (June to November) baseflow at Willow Grove (340 ML/d) plus a buffer equal to 50% of the daily demand for mine rehabilitation. The aim of the buffer was to prevent harvesting that could reduce unregulated flows to below 340 ML/d (refer explainer below).

In the very driest years, virtually no unregulated flow is available because the flow threshold for diversion is seldom reached. Under this scenario, supply for mine rehabilitation can continue at low river flows, but only if supplied from water stored in Blue Rock Reservoir.

Explainer: Setting the threshold to prevent winter-spring baseflow from being diverted buffer
The higher flow harvesting buffer was set equal to 50% of the daily demand for mine rehabilitation because at a flow of 340 ML/d at Willow Grove, the Latrobe River at Willow Grove contributes approximately 50% of the unregulated flow into Lake Narracan (i.e. at this time, the power generators would be sourcing half of their unregulated river supply from the Latrobe River at Willow Grove, and half from the Moe River, Narracan Creek and other local inflows to Lake Narracan, excluding spills and releases from Blue Rock Reservoir).
Explainer: Setting the threshold to prevent winter-spring baseflow from being diverted indicator
The use of a single indicator gauge was selected in preference to estimating total unregulated flows upstream of Lake Narracan. This was because although total unregulated flows can be estimated in the Source model, in practice it would complicate the operation of the harvesting scheme, due to its reliance on multiple streamflow gauges and the estimation of ungauged inflows and farm dam impacts. The Willow Grove gauge was adopted because it is currently active and has a reasonably continuous, long-term streamflow record, and contributes around half of all inflows within the flow range of interest. The baseflow was calculated using a digital recursive filter with filter parameter 0.925 and three passes, which is within the range adopted as part of common practice (Ladson et al., 2013).

Condition D - A limit on annual releases from Blue Rock Reservoir
Water entitlements for power generation historically had a limit on annual releases from Blue Rock Reservoir to limit high rates of drawdown of the power generators' shares of Blue Rock Reservoir – this was removed during the Millennium Drought to ensure no interruption to Victoria's power generation caused by this limit.

More extensive drawdown of the power generators' shares of Blue Rock Reservoir has the potential to reduce incidental benefits on other entitlement holders in Blue Rock Reservoir and downstream, by changing internal spills (i.e. between the various shares of storage) and external spills (refer explainer below).

An annual limit on take means that Blue Rock Reservoir is drawn down less in short droughts. Once the drought breaks, the storage fills and spills more quickly, supporting recovery of waterway health. This condition is aimed at sharing the risk of a drying climate more equitably between water users in the Latrobe River system.

Reinstating limits (with modification) on releases is considered appropriate because, unlike power generation, the supply of water for mine rehabilitation may be interrupted.

This **proposed limit on Blue Rock releases for mine rehabilitation was set at the 25th percentile annual release volume from each power generators' share of Blue Rock Reservoir**. This condition intends to restrict releases from Blue Rock for mine rehabilitation during the 25% of years with greatest releases which generally are the driest. This limit is shown in Table 3 and is based on water resource modelling results without the limit in place. This condition is applied in Scenario 4 (net take during winter/spring with annual limit) below and for scenario 5 under gross historical take with conditions in place. The caps are higher for scenario 5 than scenario 4 to reflect the higher maximum level of take for scenario 5 (which is part of Condition A).

Explainer: Internal and external spills
Eight entitlement holders each own a share of the storage capacity and inflows to Blue Rock Reservoir; effectively the reservoir is operated like eight separate storages.
Internal spill means the redistribution of inflow which occurs when a Blue Rock Entitlement Holder's share of inflow is in excess of the volume required to fill its share of storage capacity. Internal spills can influence the amount of water available to water users in a given year, but typically are an incidental benefit of another entitlement holder not fully utilising their water entitlement.
External spills occur when Blue Rock Reservoir fills to the fixed spillway level and water begins to flow over the spillway. External spills lead to larger flow events (e.g. bankfull and overbank flows) and therefore can contribute to supporting environmental and Traditional Owner values associated with these events. External spills can also lead to flooding impacts.

Table 3. Setting the cap on take for Scenario 4 and 5

	Annual releases from Blue Rock Reservoir (GL/year)			
Power generation entitlement	Average (Scenario 4 but without the cap in place)	Maximum (Scenario 4 but without the cap in place)	25th Percentile at Net Historical Take (Scenario 4)	25th Percentile at Gross Historical Take (Scenario 5)
Loy Yang A	9.4	18.0	13.7	16.7
Loy Yang B	5.9	11.3	8.3	9.8
Yallourn	5.7	11.0	8.2	17.9

Sensitivity test on notional Latrobe Reserve demand
The Latrobe water resource model was configured to include two components of the Latrobe Reserve demand in the baseline and most scenarios. These are:

1. Demand created by entitlement holders accessing the Latrobe Reserve when they face a water shortage (consistent with stated purpose of Latrobe Reserve bulk entitlement); and
2. A notional demand that is designed to minimise incidental internal spills from the Latrobe Reserve benefitting other Blue Rock Reservoir entitlement holders. Conceptually, this demand recognises that the internal spills from the Latrobe Reserve are an incidental benefit that may cease, such as following any reallocation of the Latrobe Reserve as a potential response to the 2028 review and continuing reduction in requirements for very high security of water supply for coal-fired power generation.

Given the uncertainty on future demand for the Latrobe Reserve, a sensitivity test was undertaken to consider the range of historical operating conditions (refer Appendix C2). In this sensitivity test the notional demand on the Latrobe Reserve (which is designed to minimise incidental internal spills in Blue Rock Reservoir to other entitlement holders) was set to zero. Under the baseline this results in minimal changes to supply to other water users, however for Scenario 5 (gross take during winter/spring with annual cap), there is an increase in internal spills which results in an increase supply to mine rehabilitation, and a minor increase in supply to regulated private diverters.

4.2 Scenarios

The following scenarios have been developed to test the conditions described above (Table 4). Further details and the key assumptions across the various scenarios is shown in Table 5.

Table 4. Overview of scenarios and how they link to conditions and scenarios

Conditions / sensitivity	Baseline	Scenarios				
		1	2	3	4	5
Condition A - Maximum volume for mine rehabilitation	Gross historical take	Full uptake	Net historical take			Gross historical take
Condition B - Restricting take to the wettest months of the year	No restriction on timing of take (i.e., year-round take)			Take restricted to Jun-Nov		
Condition C - A threshold to prevent winter-spring baseflow from being diverted	No threshold			Threshold included		
Condition D - A limit on annual releases from Blue Rock Reservoir	None				Capped at 25th percentile release	

Scenario 1 - Full uptake of three bulk entitlements previously held for power generation (96.5 GL/year); no other conditions on take for mine rehabilitation
Relative to the historical operation baseline, water for mine rehabilitation in scenarios is firstly (for Scenario 1) tested assuming no conditions on water harvesting, other than those conditions already specified in the power generator bulk entitlements. Demand is increased from the historical average annual demand of 62.8 GL/year, up to an assumed full uptake demand that averages 96.5 GL/year (refer Table 1 above) – modification on Condition A. Because water is used for mine rehabilitation, return flows from power generation are assumed to no longer continue under this scenario. Unregulated flow harvesting can occur up to the power generators' shares of those flows, as specified in their bulk entitlements, after allowing for any minimum passing flows downstream.

Scenario 2 - Take for mine rehabilitation capped at net historical take (NHT) of 39 GL/year
For the Scenarios 2-4, demand is reduced to the net historical take (39 GL/year) by the power generators (Condition A). These scenarios all assume no return flows. In Scenario 2 there are no conditions on taking that 39 GL/year, other than what is specified in the bulk entitlement rules. The seasonal pattern of demand is assumed to match that which occurred historically on average, less return flows from power generation. Under this scenario water access for mine rehabilitation would only be restricted (within the bulk entitlement diversion rules) if the power generators' shares of Blue Rock Reservoir are exhausted.

Scenario 3 - Capped each year at net historical take (39 GL/year) from June to November, with a threshold to prevent winter-spring baseflow from being diverted
For Scenario 3, additional conditions on take for mine rehabilitation are introduced, in order to potentially mitigate some of the impacts on other water users and the environment when power generator return flows cease. This scenario promotes harvesting of unregulated flows for mine rehabilitation in wetter periods and restricts harvesting during drier periods (Condition B). This scenario assumes that:

- Water for mine rehabilitation only occurs from 1 June to 30 November. The daily harvest rate was changed to retain the same annual demand of 39 GL/year for mine rehabilitation, equivalent to the historical net take by the power generators.

- Harvesting of unregulated flows for mine rehabilitation only occurs when flows at Willow Grove are above 447 ML/d (Condition C).

Scenario 4 - Capped each year at net historical take (39 GL/year) from June to November, with a threshold to prevent winter-spring baseflow from being diverted, plus an annual limit on releases from Blue Rock Reservoir for mine rehabilitation

For Scenario 4, in addition to the conditions tested in scenarios 2 and 3, a cap on annual releases from Blue Rock Reservoir by the power generators was introduced to limit high rates of drawdown of the power generators' shares of Blue Rock Reservoir (Condition D). This cap on Blue Rock releases for mine rehabilitation was set at the 25th percentile annual release volume from each power generators' share of Blue Rock Reservoir.

Scenario 5 - Capped each year at gross historical take (GHT) of 63 GL/year from June to November, with a threshold to prevent winter-spring baseflow from being diverted, plus an annual limit on releases from Blue Rock Reservoir for mine rehabilitation

For Scenario 5, Scenario 4 was re-run but at a higher level of demand equal to the gross historical take of 62.8 GL/year, rather than the net historical take of 39 GL/year (refer Table 1 above) – modification of Condition A.

Due to the higher maximum total volume, the adopted limits on Blue Rock Reservoir releases were adjusted accordingly. The adopted limits are shown in Table 3 above.

Table 5 Overview of key assumptions

<table>
<tr><th></th><th>Baseline</th><th>Scenario 1</th><th>Scenario 2</th><th>Scenario 3</th><th>Scenario 4</th><th>Scenario 5</th></tr>
<tr><td>Demand volume (mine rehabilitation / power generation)</td><td>Gross historical take
62.8 GL/yr</td><td>Full uptake
96.5 GL/yr</td><td colspan="3">Net historical take
39.0 GL/yr</td><td>Gross historical take
62.8 GL/yr</td></tr>
<tr><td>Demand pattern (mine rehabilitation / power generation under baseline)</td><td colspan="3">All year</td><td colspan="3">Jun-Nov, constant over these months</td></tr>
<tr><td>Unregulated flow harvesting for mine rehabilitation / power generation</td><td colspan="3">Current</td><td colspan="3">A threshold to prevent winter-spring baseflow from being diverted</td></tr>
<tr><td>Annual cap on releases from Blue Rock for mine rehabilitation / power generation</td><td colspan="4">None</td><td colspan="2">Capped at 25th percentile release</td></tr>
<tr><td>Return flows [15]</td><td>APM [16], GW WWTPs, Yallourn, Loy Yang</td><td colspan="5">APM, GW WWTPs</td></tr>
<tr><td>3-4 Bench demand [17]</td><td colspan="6">14.4 GL/year, constant throughout year</td></tr>
<tr><td>GW additional notional future industrial demand</td><td colspan="6">20 GL/year, based on historical average monthly pattern of use by Hazelwood and Energy Brix</td></tr>
<tr><td>Latrobe Reserve demand – supply shortfalls</td><td colspan="6">Access to the reserve during supply shortfalls (variable demand typically active during drought).
No access to the Latrobe Reserve for mine rehabilitation.</td></tr>
<tr><td>Notional Latrobe Reserve demand to minimise incidental internal spills</td><td colspan="6">12 GL/year, constant throughout the year</td></tr>
</table>

[15] The catchment inflows, Gippsland Water Factory supply, Australian Paper Manufacturers (APM) return flows, and Gippsland Water's town wastewater treatment plant discharges (GW WWTPs) are equal across all baselines and scenarios. Only the power generator return flows (Loy Yang A, Yallourn) are different due to the assumed cessation of Loy Yang and Yallourn return flows under the mine site rehabilitation scenarios

[16] Note that water resource modelling was undertaken prior to the announcement of the APM Maryvale Mill ceasing production of white paper on 21 January 2023.

[17] The demand from the 3-4 Bench is a notional demand to minimise spills to other shares in Blue Rock Reservoir, and may not therefore accurately reflect reliability of supply for any future use of the 3/4 Bench for specific purposes.

5 Water availability to entitlement holders

This section provides the outcomes for existing water users for the mine rehabilitation scenarios. The following metrics are used to measure reliability of supply.

5.1 Water balance overview

Broad changes in river and supply system behaviour are indicated in the Latrobe River basin water balance in Table 6. This table highlights that on average:

- Total inflows (catchment inflows plus return flows and recycled water) are lower under the mine rehabilitation scenarios than under the baseline, because of the reduction in return flows from power generators (which are counted as an inflow because they are made available for diversion and for environmental/cultural flows at the discharge locations);
- Average annual supply to all consumptive water users (excluding water for mine rehabilitation and power generation) was essentially unchanged under the mine rehabilitation scenarios, relative to the baseline, except for private diverters along the Latrobe River supplied from SRW’s Latrobe River bulk entitlement.
- Average annual supply to private diverters along the Latrobe River supplied from SRW’s Latrobe River bulk entitlement was estimated to change from 9.3 GL/year under the baseline, to 8.9-9.5 GL/year under the mine rehabilitation scenarios.
- Average annual supply to the VEWH’s environmental entitlement in Blue Rock Reservoir was largely unchanged under mine rehabilitation scenarios relative to the baseline.
- Average annual Latrobe River flows upstream of the Thomson River (from minimum passing flows and unregulated flows) under the mine rehabilitation scenarios, with demands at average net historical take, were similar to the baseline. Compared to the baseline Latrobe River flows were lower for Scenario 1 (at full uptake demand) by around 8% and Scenario 5 (at average gross historical take) by around 3%.
- The historical incidental benefits experienced by both irrigators and the environment from having access to return flows from mine sites and the underuse of entitlements by power generators can be observed through a comparison of water balance outcomes between the baseline and Scenario 1 (full uptake of entitlements). For instance, the average annual volume available for irrigators in the lower Latrobe decreased from 9.3 GL/year under the baseline to 8.9 GL/year in Scenario 1. Also, the total outflows upstream of the Thomson River in the Latrobe River decrease from 678.3 GL/year in the baseline to 622.9 GL/year in Scenario 1.

Small differences in supply across the mine rehabilitation scenarios for the Latrobe River irrigators and the environmental entitlement were due to incidental differences in access to unregulated flows from upstream of Lake Narracan (as a result of different patterns and volumes of use by the power generators), as well as incidental changes in internal spills to other shares in Blue Rock Reservoir from the power generator shares. These changes also affect supply to the notional demand on the Latrobe Reserve, as a result of different levels of take by entitlement holders from the Latrobe Reserve during times of water shortage. Small differences in losses across mine rehabilitation scenarios were due to changes in the volume in Blue Rock Reservoir as a result of different patterns and volumes of use by the power generators.

Table 6. Average Annual Water Balance, Jul 1957 to June 2020 (GL/year) for Baseline and Scenarios under post-1975 climate conditions

		Baseline	Mine Rehabilitation Scenarios				
Water Balance Category	Water Balance Item	Baseline (historical power generation)	Scenario 1: Full uptake demand, no conditions	Scenario 2: Net historical take, no conditions	Scenario 3: Net historical take during June to Nov & threshold on unregulated flow harvesting	Scenario 4: Net historical take, with all conditions	Scenario 5: Gross historical take, with all conditions
	Catchment inflows	837.3	837.3	837.3	837.3	837.3	837.3
	Return flows and recycled water	44.4	20.6	20.6	20.6	20.6	20.6
Total inflows		**881.7**	**857.9**	**857.9**	**857.9**	**857.9**	**857.9**
	Net farm dam supply	21.1	21.1	21.1	21.1	21.1	21.1
	Urban supply	11.7	11.7	11.7	11.7	11.7	11.7
	Industrial supply under Gippsland Water bulk entitlement	49.6	49.6	49.7	49.6	49.6	49.6
	Power generation supply under generator bulk entitlements						
	Loy Yang A	21.1	0.0	0.0	0.0	0.0	0.0
	Loy Yang B	14.7	0.0	0.0	0.0	0.0	0.0
	Yallourn	27.0	0.0	0.0	0.0	0.0	0.0
Total power generation supply		**62.8**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**
	Private diversions under SRW's Latrobe River bulk entitlement[#]	9.3	8.9	9.2	9.5	9.5	9.5
	Other rural private diversions	18.7	18.7	18.7	18.7	18.7	18.7
	Notional demand on 3-4 Bench	14.4	14.4	14.4	14.4	14.4	14.4
	Notional demand on Latrobe Reserve	11.9	11.6	11.9	11.8	11.8	11.7
Total diversions excluding water for mine rehabilitation		**199.5**	**136.0**	**136.7**	**136.9**	**136.9**	**136.8**
Water for mine rehabilitation							
	Loy Yang A	0.0	39.7	16.8	16.8	16.5	20.5
	Loy Yang B	0.0	19.9	11.7	11.5	11.1	13.3
	Yallourn	0.0	36.3	10.4	10.4	10.1	24.3
Total water for mine rehabilitation		**0.0**	**95.9**	**39.0**	**38.7**	**37.7**	**58.1**

Water Balance Category	Water Balance Item	Baseline	Mine Rehabilitation Scenarios				
		Baseline (historical power generation)	Scenario 1: Full uptake demand, no conditions	Scenario 2: Net historical take, no conditions	Scenario 3: Net historical take during June to Nov & threshold on unregulated flow harvesting	Scenario 4: Net historical take, with all conditions	Scenario 5: Gross historical take, with all conditions
Losses (net evaporation from reservoirs)		3.6	3.5	3.6	3.6	3.6	3.4
Outflows							
	Latrobe River environmental entitlement	15.9	15.6	15.8	15.9	15.9	15.8
	Latrobe River flows upstream of Thomson River (excl environmental entitlement)	662.4	607.3	662.5	662.8	663.7	644.4
	Total outflows (Latrobe River upstream of Thomson River)	**678.3**	**622.9**	**678.4**	**678.7**	**679.6**	**660.2**
Increase in storage		0.2	-0.4	0.2	0.0	0.0	-0.7

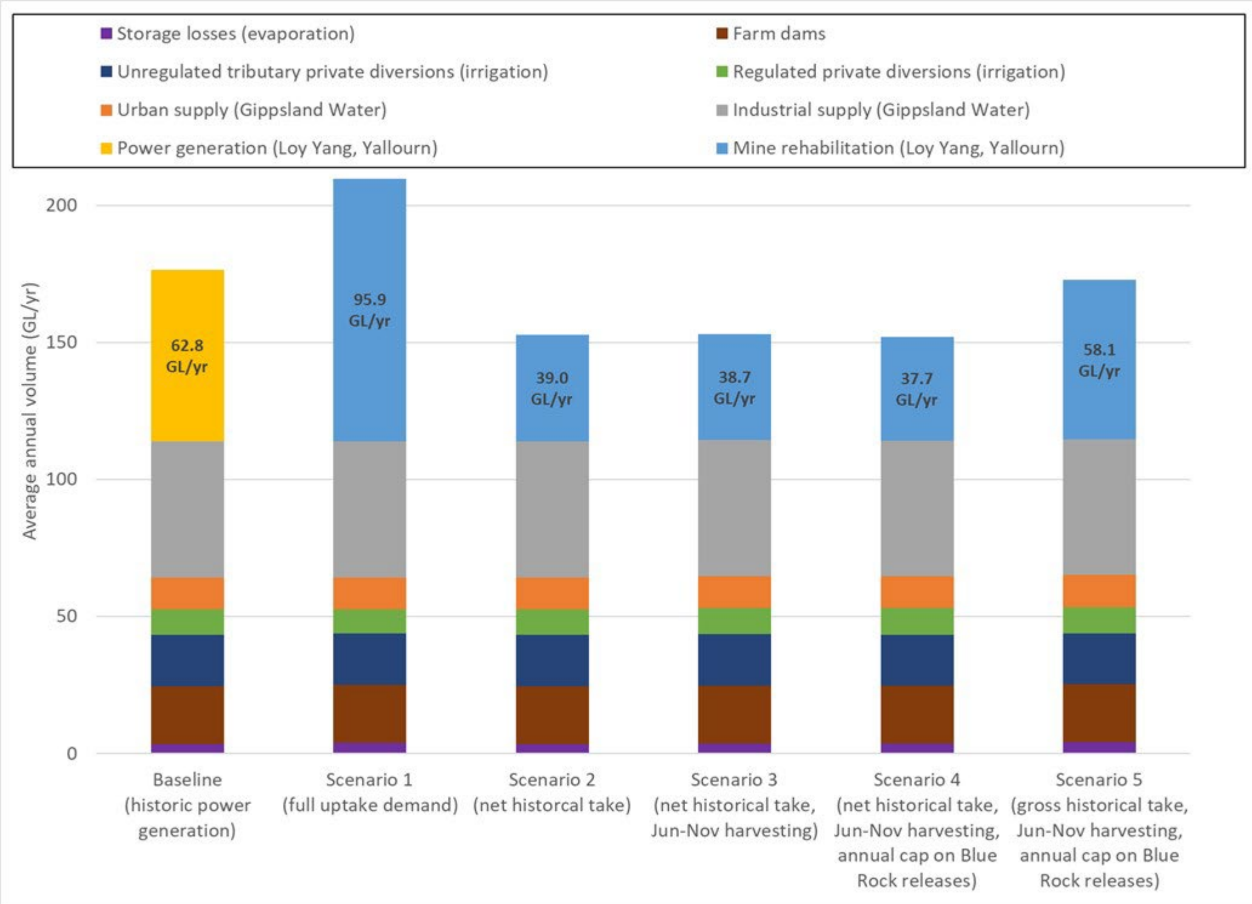
*Inflows include volumes intercepted by catchment farm dams that do not reach the waterways (refer line item "Farm dam impacts"), and exclude Thomson River.

^These represent the sum of take under Southern Rural Water's bulk entitlement and assumed take from the Latrobe Reserve to make up shortfalls.

[#]Includes some off-quota deliveries (~346 ML/year or ~4% of irrigator supply on average) that are triggered by regulated environmental entitlement deliveries from Blue Rock Reservoir

Note: The water balance results show that there is no mass balance error.

The distribution of available water to consumptive uses within this water balance is represented visually in Figure 2.



Notes:
The available water includes volumes intercepted by catchment farm dams that do not reach the waterways (refer "Farm dams") and exclude Thomson River.
Regulated private diversions (irrigation) represent the sum of take under Southern Rural Water's bulk entitlement and assumed take from the Latrobe Reserve to make up shortfalls. It includes some off-quota deliveries (~346 ML/year or ~4% of irrigator supply on average) that are triggered by regulated environmental entitlement deliveries from Blue Rock Reservoir.

Figure 2. *Distribution of available water for consumptive users under baseline and mine rehabilitation scenarios over the post-1975 historic climate reference period.*

5.2 Supply for mine rehabilitation

The water balance (presented earlier in Table 6) indicated that the average annual supply of water for mine rehabilitation would reduce from the historical net take of 39.0 GL/year to 38.7 GL/year with supply restricted to the June to November period and with harvesting of unregulated flows limited to higher flow periods. When an annual cap on Blue Rock releases from the power generator bulk entitlements is introduced, average annual supply reduces to 37.7 GL/year (i.e. 97% of the historical net take).

The annual time series of supply for mine rehabilitation from the Loy Yang A, Loy Yang B and Yallourn entitlements respectively is provided in Appendix C1, which demonstrate that:

- Supply from all power generator bulk entitlements is estimated to be maintained in every year over the period of assessment, when supplying water at the historical annual net take all year round without conditions (Scenario 2).
- When demand for mine rehabilitation is shifted to the June to November period and the harvesting of unregulated flows is restricted to higher flow periods (Scenario 3), supply from the Loy Yang A and

Yallourn entitlements is estimated to be maintained in every year over the period of assessment. Supply from the Loy Yang B bulk entitlement is reduced in 4 out of 63 years of the assessment period, with a minimum annual supply volume of 5.2 GL/year (relative to the unrestricted demand from the Loy Yang B entitlement of 11.8 GL/year).

- When the annual cap on releases from Blue Rock Reservoir is also introduced (Scenario 4), supply from all three bulk entitlements is maintained in most years, but is restricted in dry years. Maximum and minimum annual supply volumes, and annual supply reliability, are presented in Table 7. Comparing scenarios with a similar level of demand for mine rehabilitation (e.g. the average annual demand is 39 GL/yr under Scenarios 2-4) demonstrates the relative effect of each of these conditions at the same level of demand.
- Reliability of supply for mine rehabilitation at net historical take without conditions is very high (>99% of years with no supply shortfalls), and the same as reliability of supply for current power generation activities. This is because the bulk entitlements were originally designed to provide a very reliable supply for power generation, with net historical take of 39 GL/year well below the maximum allowable annual demand of 96.5 GL/year, and the ability to draw on water held in storage in Blue Rock Reservoir when needed.

Table 7. Annual Supply for Mine Rehabilitation (Note that Scenario 5 is at a different level of take from Scenarios 2,3,4)

Scenario	Bulk Entitlement	Maximum Annual Supply (GL/year)	Minimum Annual Supply (GL/year)	Annual Reliability of Supply (% of years with demand[18] fully supplied)	Minimum no. of days of supply in driest year (from all sources)
Scenario 2: net historical take, no conditions	Loy Yang A	18.1	15.8	>99%	365
	Loy Yang B	12.6	11.0	>99%	364
	Yallourn	14.5	7.5	>99%	335
	Total	43.9	35.0	>99%	Not assessed
Scenario 3: net historical take only in winter/spring, threshold on unregulated flow harvesting	Loy Yang A	16.8	16.8	>99%	182
	Loy Yang B	11.7	5.2	94%	181
	Yallourn	10.4	10.4	>99%	182
	Total	39.0	32.4	94%	Not assessed
Scenario 4: net historical take, with all conditions	Loy Yang A	16.8	13.7	78%	149
	Loy Yang B	11.7	8.3	67%	130
	Yallourn	10.4	8.2	73%	143
	Total	39.0	30.2	67%	Not assessed
Scenario 5: gross historical take, with all conditions	Loy Yang A	21.1	15.5	75%	145
	Loy Yang B	14.7	3.3	59%	131
	Yallourn	27.0	6.1	59%	131
	Total	62.8	26.2	59%	Not assessed

In the table above, the annual reliability of supply for the sum of all power generators was the same as the

[18] Modelled demand is based on the maximum annual volume under the relevant scenario.

lowest annual reliability of the individual power generators. This is because when supply from any individual entitlement is less than its demand, the total supply from all entitlements will always be less than the total demand from those entitlements.

The seasonal pattern of releases from Blue Rock Lake changes under the mine rehabilitation scenarios when supply for mine rehabilitation is constrained to the winter/spring period, as shown in Figure 3. In this figure, the releases are higher under Scenario 3 (on the right) because more releases are needed to offset the reduction in access to unregulated flows.

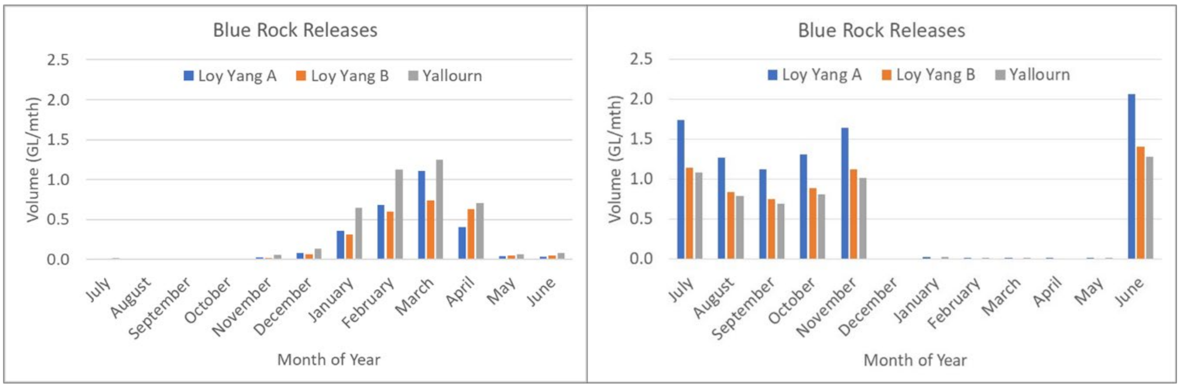


Figure 3. *Change in seasonal pattern of Blue Rock Reservoir releases from power generator entitlements under the baseline (left) and for mine rehabilitation with June to November harvesting at average historical net take (Scenario 3)*

5.3 Impact on consumptive users

Table 8 shows the reliability of supply performance indicators for consumptive water users across the scenarios tested.

Irrigation supply reliability for private diverters supplied from SRW's Latrobe River bulk entitlement reduces (measured as the number of years in which less than 1% of the capacity of Blue Rock Reservoir is accessed from the Latrobe Reserve [19]) from 98% under the baseline to 86-90% under the mine rehabilitation scenarios. This translates, on average over the long-term, to needing to access more than 1% of the capacity of Blue Rock Reservoir from the Latrobe Reserve approximately 1 in every 9-10 years rather than approximately 1 in every 50 years.

Figure 4 shows the range of annual volumes accessed from the Latrobe Reserve under the baseline and scenarios. Restricting mine rehabilitation to the winter/spring period (Scenarios 3 and 4, which plot on top of one another in Figure 4) did not result in increases in reliability of supply to rural private diverters relative to Scenario 2 (net take, no other conditions). This was a result of the higher daily demand for water for mine rehabilitation over winter-spring drawing down the volume held in the power generator shares of storage over these months, thereby reducing or preventing internal spills to Southern Rural Water in some years.

The net average annual internal spills to Southern Rural Water were reduced by 0.5 GL/year when comparing scenarios 2 and 3, noting that reductions in spills to Southern Rural Water are typically larger in drought years when those internal spills are more valuable to irrigators, such as 1-2 GL/year in 1967/68, 1982/83, and some years over the Millennium Drought.

[19] The 2022 Central and Gippsland Region SWS recommitted to an additional 1% share of Blue Rock Reservoir being made available for irrigators as pledged in the 2011 Gippsland Region Sustainable Water Strategy. However, it is important to note that how that water is made available will be decided in consultation with stakeholders and with regard to a concurrent commitment to reallocate 16 GL from the 3-4 Bench bulk entitlement to support irrigation, environmental values and Traditional Owner self-determined outcomes. Hence, the definition of reliability of supply used here is nominal only, reflecting a system in transition.

The incidental benefit to private diverters can be demonstrated in the reliability (% of years when <1% of Blue Rock capacity is accessed from the Latrobe Reserve) of 98% under the baseline (historic use for power generation), compared to 86% under Scenario 1 (use of full entitlements for mine rehabilitation).

Reliability of supply to urban water users is unchanged. Reliability of supply to the 3/4 Bench is also unchanged – acknowledging that this is based on the notional demand placed on the 3/4 Bench, and may not therefore accurately reflect reliability of supply for any future use of the 3/4 Bench for specific purposes.

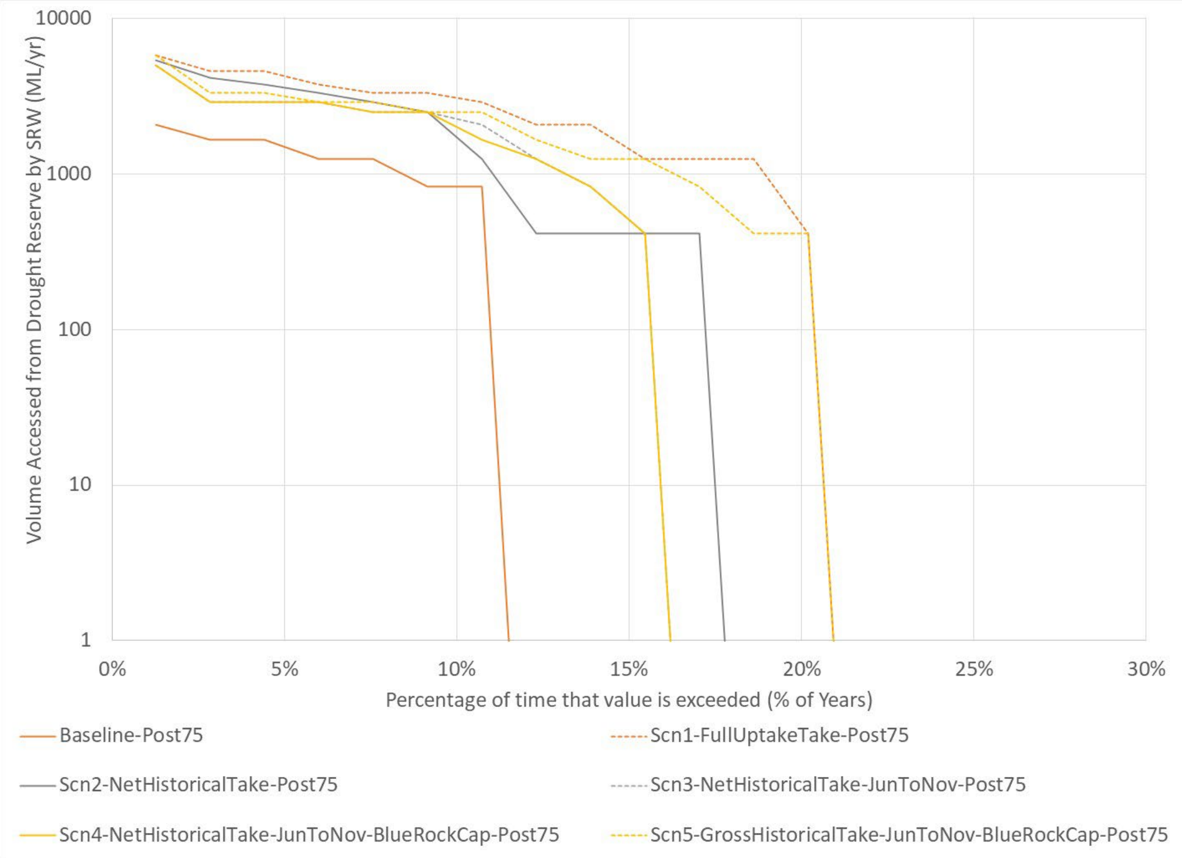


Figure 4. *Annual volume accessed from Latrobe Reserve by SRW*

Table 8 Reliability of Supply Performance Indicators, Jul 1957 to June 2020

	Baseline	Mine Rehabilitation Scenarios				
Indicator	Baseline (historical power generation)	Scenario 1: Full uptake demand, no conditions	Scenario 2: Net historical take, no conditions	Scenario 3: Net historical take during June to Nov & threshold on unregulated flow harvesting	Scenario 4: net historical take, with all conditions	Scenario 5: Gross historical take, with all conditions
Irrigation Annual Reliability (% of years when Latrobe Reserve is not accessed)	89%	79%	83%	84%	84%	79%
Irrigation Annual Reliability (% of years when <1% of Blue Rock capacity is accessed from the Latrobe Reserve)	98%	86%	90%	89%	90%	89%
Urban Annual Reliability for Blue Rock / Moondarra System (% of years without restrictions)	>99%	>99%	>99%	>99%	>99%	>99%
Urban Annual Reliability for Mirboo North (% of years without restrictions)	>99%	>99%	>99%	>99%	>99%	>99%
Power Generator Reliability for 3/4 Bench (% of years when Latrobe Reserve is not accessed)	>99%	>99%	>99%	>99%	>99%	>99%
Power Generator Reliability for Loy Yang A (% of years when Latrobe Reserve is not accessed)	>99%	N/a	N/a	N/a	N/a	N/a
Power Generator Reliability for Loy Yang B (% of years when Latrobe Reserve is not accessed)	>99%	N/a	N/a	N/a	N/a	N/a
Power Generator Reliability for Yallourn (% of years when Latrobe Reserve is not accessed)	>99%	N/a	N/a	N/a	N/a	N/a

N/a indicates that this metric is not applicable because the power generators are assumed to not have access to the Latrobe Reserve for these scenarios. Refer to Table 7 for reliability of supply indicators for mine site rehabilitation

5.4 Seasonal demand for mine rehabilitation and irrigation

Historically the seasonal demand for power generation and irrigation have overlapped, with the highest demand for both uses during the hotter and drier months of the year. This overlap is evident in the baseline as illustrated for an example year in Figure 5. This example year (2017/18) was a moderately dry year. Overlap does not necessarily mean competition for unregulated streamflows as all demands can be met when there is plentiful water. However, under mine rehabilitation scenarios, any overlap in demand would result in less water flowing through to irrigators downstream on days when diversions for mine rehabilitation were occurring, relative to scenarios where those diversions do not occur during periods of irrigation demand.

The avoidance of potential overlap of demand for water between irrigators and water for mine rehabilitation is illustrated in Figure 6 for Scenario 3, which restricts supply for mine rehabilitation to the months of June to November and only allows unregulated flow harvesting on days when the flow at Willow Grove is above the median winter-spring baseflow. It can be seen in Figure 6 that there is only minor overlap of demand for both purposes in October and November, with no concurrent demand for unregulated flows over the peak irrigation demand months through to the end of May. In this example year, which is a moderately dry year, the flow at Willow Grove was below the median winter-spring baseflow throughout October and November, hence there was no harvesting of unregulated flows for mine rehabilitation in these two months, and hence no unregulated flow harvesting for mine rehabilitation concurrent with irrigators.

Even though the shifting of mine rehabilitation demand to the months of June to November avoids direct competition for unregulated flow harvesting with irrigators, as noted previously in Section 5.3, this seasonal shift in demand still causes a reduction in internal spills from the power generators' shares to Southern Rural Water's share of Blue Rock Reservoir.

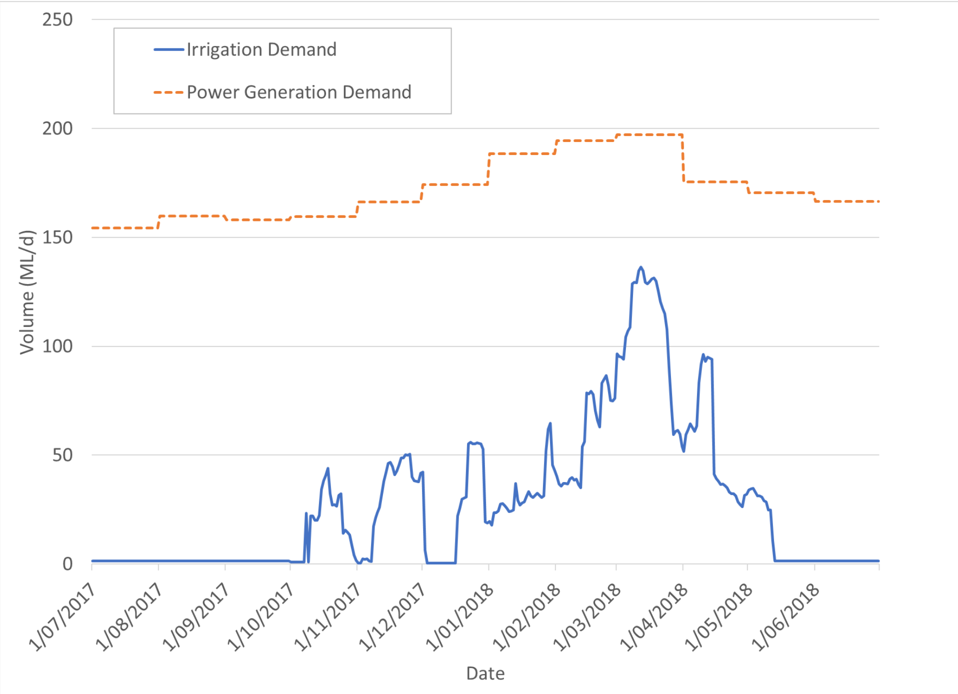


Figure 5. *Modelled seasonal demand for water by power generators and irrigators under baseline conditions for July 2017 – June 2018*

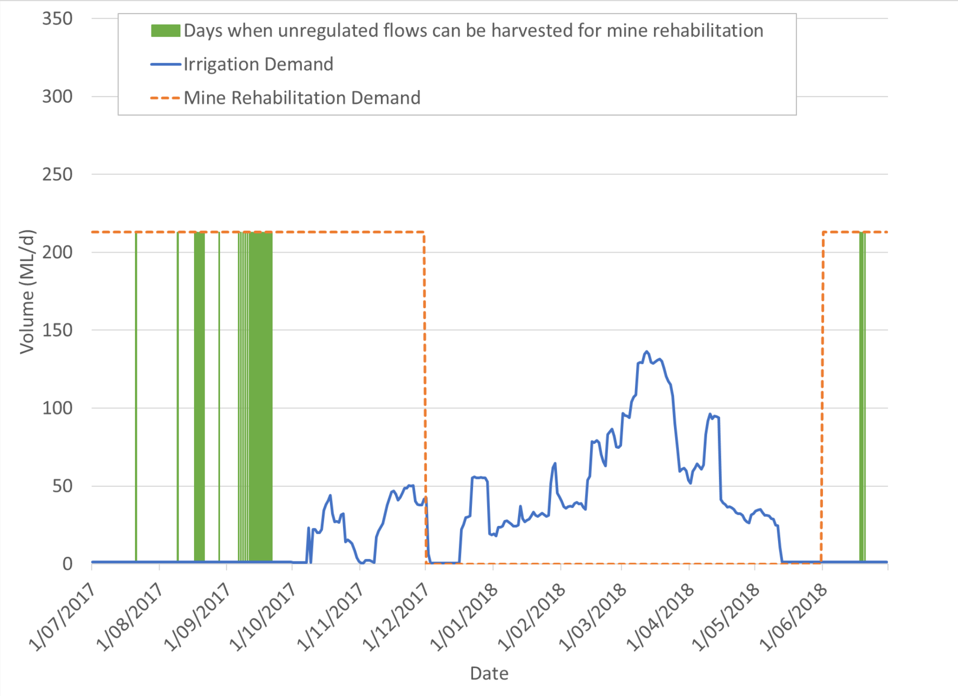


Figure 6. *Modelled demands for water for mine rehabilitation and irrigation under Scenario 3 (noting the mine rehabilitation demand has been modelled as a static demand across the winter-spring period which is less than the existing combined maximum extraction rate for Yallourn, Loy Yang A and Loy Yang B of 366 ML/day).*

5.5 Impacts on access to water for the environment

The average annual water balance indicated a marginal increase (<0.2%) in average annual streamflow in the Latrobe River upstream of the Thomson River under the net historical take mine rehabilitation scenarios (Scenarios 2-4) relative to the baseline (refer Section 5.1).

Average annual supply to the VEWH's Blue Rock Environmental Entitlement (EE) was largely unchanged under the mine rehabilitation scenarios relative to Baseline, with a reduction of 2% under Scenario 1 (at full uptake demand), a reduction of less than 1% under Scenario 2 (with higher seasonal demand) and 5 (at gross historical take), and no change under Scenarios 3 and 4 (at net historical take).

A detailed assessment of the impacts of mine rehabilitation on risks to the environment and Traditional Owner values is included in Sections 6 and 7.

5.6 Sensitivity under projected year 2065 climate change

There is considerably less water available under the projected high climate change projection than the low climate change projection for the year 2065. Latrobe River inflows are projected to be 350 GL/year lower (~42% lower) on average under the 2065 high climate change projection (relative to both the post-1975 historic climate reference period and the year 2065 low climate change projection), with much lower volumes held in storage, less frequent spills from storages, and lower reliability of supply to most water users (Table 9).

Water for mine rehabilitation would be significantly lower under year 2065 high climate change, relative to that under both the post-1975 historic climate reference period and year 2065 low climate change conditions (Table 10). Minimum annual volumes available for mine rehabilitation under year 2065 high climate change could approach zero in drought years - noting that this corresponds to a repeat of the Millennium Drought under a high climate change projection.

An illustration of the change in storage in Blue Rock Reservoir under climate change is presented in Figure 7. This figure highlights that climate change could significantly alter river and supply system behaviour.

The effect of losing climate resilient return flows from mine sites and the potential impacts on reliability for rural private diverters is shown in Table 9, with much lower decrease in reliability under the 2065 high climate change projection under the baseline than Scenario 4 and 5.

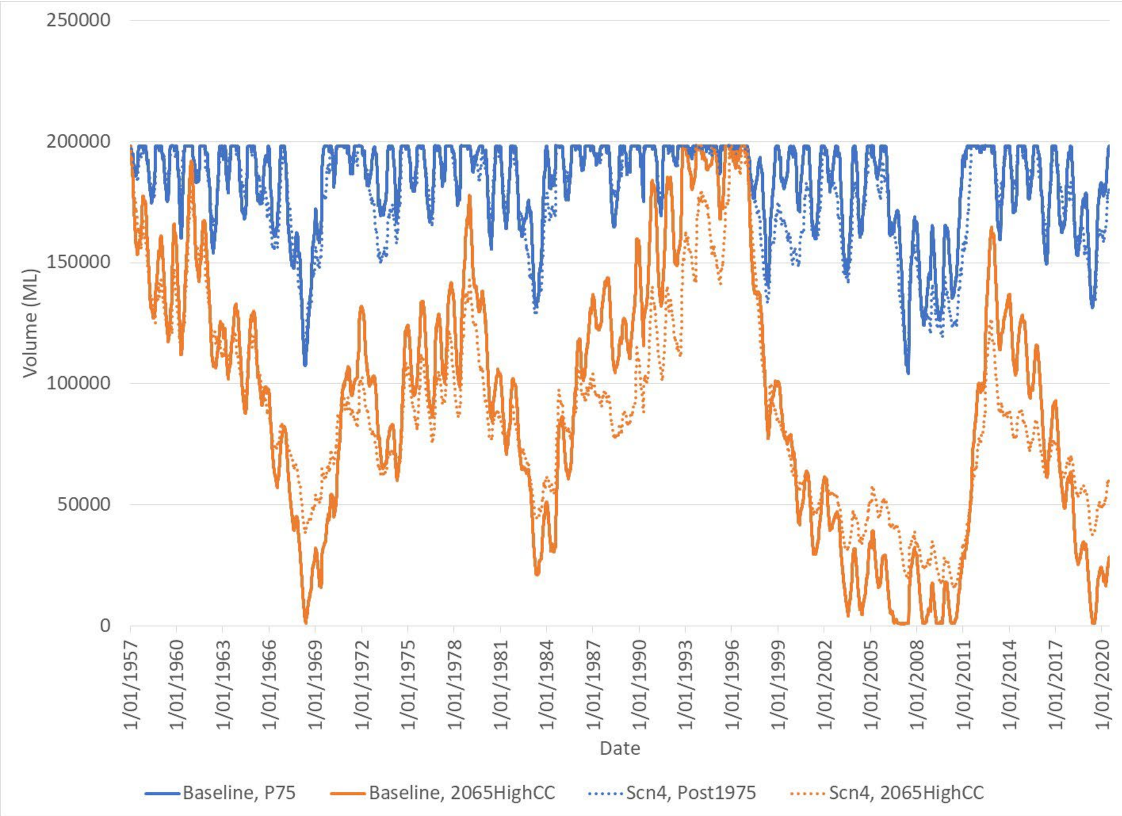


Figure 7. *Volume in Blue Rock Reservoir under projected year 2065 high climate change and the post-1975 historic climate reference period. Sample scenario: scenario 4 (net historical take with conditions in place)*

The distribution of available water under the projected 2065 high climate change projection is shown in Figure 8.

Results for other scenarios under year 2065 high climate change were similar to those presented for Scenario 4. These include:

- A similarly low annual frequency of spills from Blue Rock Reservoir (0% for Scenario 5 compared to 3% under Scenario 4)
- Identical average annual supply (8 GL/year) and similar annual reliability (32% for Scenario 5 compared to 35% under Scenario 4)
- The same urban annual reliability of supply (71%) between Scenario 4 and Scenario 5
- Similar minimum annual supply for mine rehabilitation as Scenario 4 (e.g. Loy Yang A minimum annual supply is 0.6 GL/year under Scenario 5, relative to 0.6 GL/yr under Scenario 4), but slightly higher average and maximum annual supply (e.g. maximum annual supply to Loy Yang A of 21 GL/yr under Scenarios 5, relative to 16 GL/yr under Scenario 4) and slightly lower annual reliability of supply. This is due to the higher input demand (gross historical take under Scenario 5, rather than net historical take under Scenario 4)

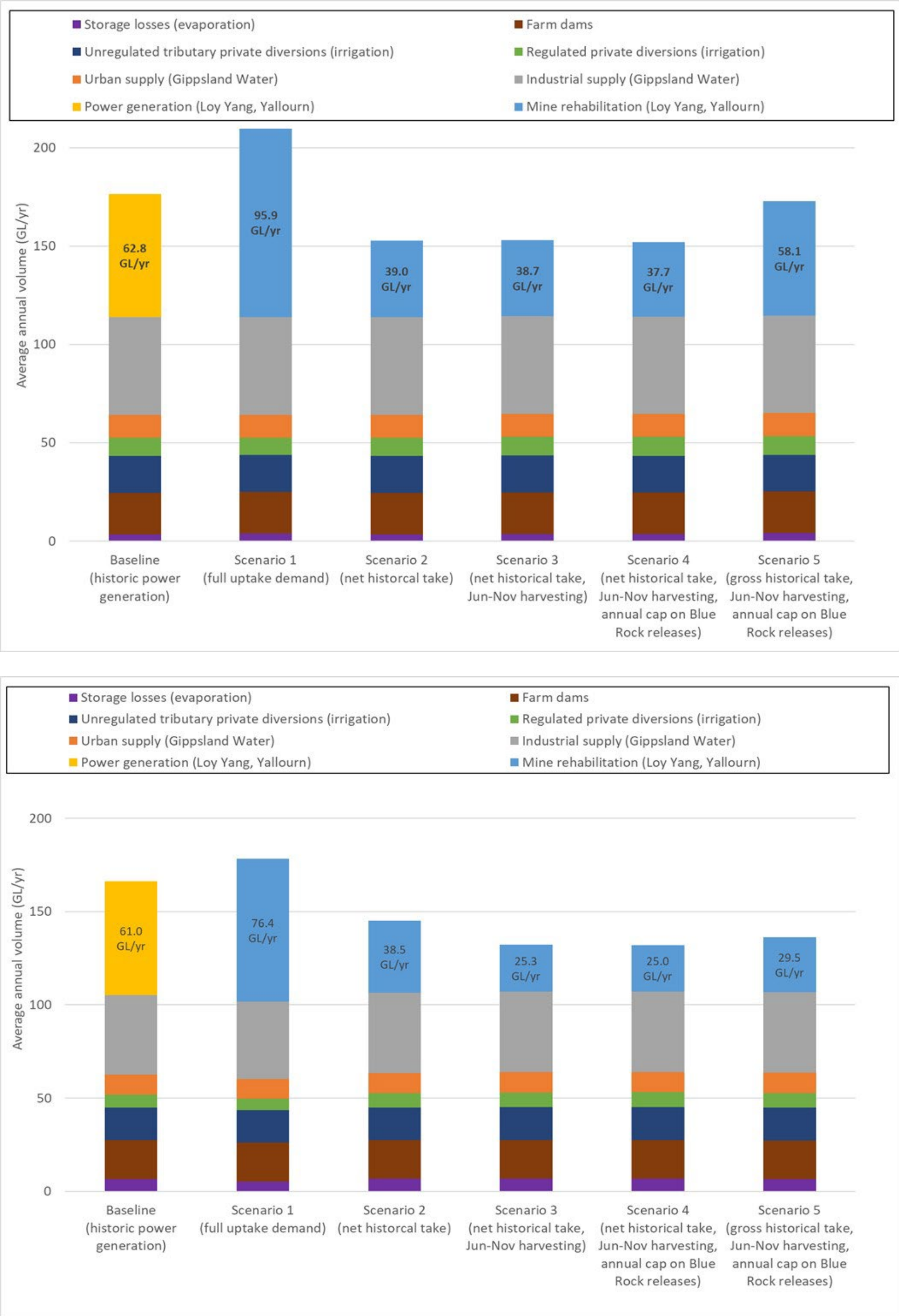


Figure 8. *Distribution of available water for consumptive users under baseline and mine rehabilitation scenarios. the post-1975 historic climate reference period (top) and year 2065 high climate change (bottom)*

Notes:

The available water includes volumes intercepted by catchment farm dams that do not reach the waterways (refer “Farm dams”), and exclude Thomson River.

Regulated private diversions (irrigation) represent the sum of take under Southern Rural Water’s bulk entitlement and assumed take from the Latrobe Reserve to make up shortfalls. It includes some off-quota deliveries (~346 ML/year or ~4% of irrigator supply on average) that are triggered by regulated environmental entitlement deliveries from Blue Rock Reservoir.

Table 9. Performance metrics under projected year 2065 climate change for the baseline and scenarios 4 and 5

Baseline or Scenario:	Baseline (historical power generation)		Scenario 4: Net historical take, with all conditions		Scenario 5: Gross historical take, with all conditions	
Climate Conditions:	Post-1975 historic climate and 2065 low climate change*	2065 high climate change	Post-1975 historic climate and 2065 low climate change*	2065 high climate change	Post-1975 historic climate and 2065 low climate change*	2065 high climate change
Frequency of spills from Blue Rock Reservoir (% of years)	84%	8%	63%	3%	49%	0%
Average annual spills from Blue Rock Reservoir (GL/year)	49	2	40	<1	33	0
Average annual supply to private diverters under SRW's Latrobe River bulk entitlement (GL/year)	9.3	7	9.5	8	9.5	8
Irrigation Annual Reliability (% of years when <1% of Blue Rock capacity is access from the Latrobe Reserve)	98%	81%	90%	35%	89%	32%
Urban Annual Reliability for Blue Rock / Moondarra System (% of years without restrictions)	>99%	70%#	>99%	71%#	>99%	71%#

* River and supply system behaviour under the post-1975 historic climate reference period conditions is a reasonable indicator of behaviour under the projected 2065 low climate change scenario. Year 2065 low climate change conditions have been modelled for the baseline and all scenarios, but have not been reported in this table.

In the absence of actions by Gippsland Water under its Urban Water Strategy to maintain urban reliability of supply

Table 10 Annual Supply for Mine Rehabilitation for scenario 4 (average net historical take, conditions in place) and scenario 5 (average gross historical take, conditions in place)

Scenario	Climate scenario	Bulk Entitlement	Maximum annual supply (GL/year)	Minimum annual supply (GL/year)	Annual Reliability of Supply (% of years with demand[20] fully supplied)	Minimum no. of days per year with any supply
Scenario 4 (average net historical take, conditions in place)	Post-1975 climate and Year 2065 low climate change*	Loy Yang A	16.8	13.7	78%	149
		Loy Yang B	11.7	8.3	67%	130
		Yallourn	10.4	8.2	73%	143
		Total	39.0	30.2	67%	Not assessed
	Year 2065 high climate change	Loy Yang A	16.8	0.6	24%	6
		Loy Yang B	11.7	0.3	13%	5
		Yallourn	10.4	0.5	25%	8
		Total	39.0	1.4	13%	Not assessed
Scenario 5 (average gross historical take, conditions in place)	Post-1975 climate and Year 2065 low climate change*	Loy Yang A	21.1	15.5	75%	145
		Loy Yang B	14.7	3.3	59%	131
		Yallourn	27.0	6.1	59%	131
		Total	62.8	26.2	59%	Not assessed
	Year 2065 high climate change	Loy Yang A	21.1	0.6	14%	5
		Loy Yang B	14.7	0.4	3%	5
		Yallourn	27.0	0.6	3%	4
		Total	62.8	1.6	8%	Not assessed

* River and supply system behaviour under post-1975 climate conditions has been used as an indicator of behaviour under projected year 2065 climate conditions

[20] Modelled demand is based on the maximum annual volume under the relevant scenario.

6 Risk assessment for Traditional Owner and environmental values

As highlighted in Section 2.2, the key LVRRS implementation principle relevant for this study is that "any water used for mine rehabilitation should not negatively impact on Traditional Owners' values, environmental values of the Latrobe River system or the rights of other existing water users." This assessment aims to investigate the risk of potential impacts to Traditional Owner and environmental values.

Unlike the performance metrics for entitlement holders outlined in Section 5, understanding the changes in risk to environmental and Traditional Owner values requires development of a robust and transparent approach specific to this project. Therefore, the following section outlines the risk assessment framework and scope, while detailed steps are included in Appendix A1 and supporting information is included in Appendices A2-A5.

A risk panel was formed to provide advice and interpretation to inform the risk assessment from a freshwater ecology perspective. The risk panel included Barry Hart[21] and Nick Bond[22]. The project team worked closely with GLaWAC, who were supported by the WGCMA, to develop the Traditional Owner value components of the assessment.

For this assessment, risk is defined as the effect of a given water management scenario on Environmental values and Traditional Owner cultural values. The risk assessment focuses on the risk under the Baseline and whether the scenarios change the risk relative to the Baseline.

The following framework will be used to assess risk.

- **Consequence** is the effect on values if the hydrological regime of the given scenario does not support the values. Embedded within the consequence assessment is a ranking of the relative importance of the value or consequence of its loss. This assessment is informed by the value and the location of the value.
- **Likelihood** is the probability that the hydrological regime impacts the values. This element comprises two components
    - A measure of performance of the hydrological regime against recommended flow components
    - A measure of the strength or importance of the relationship between the flow component and the value of interest

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[21] Emeritus Professor Barry specialises in natural resources decision-making (water quality and catchment management, environmental flows, water policy) and ecological risk assessment, and is a member of many independent scientific inquiries, reviews and advisory committees.

[22] Professor Nick Bond is the Director of the Centre for Freshwater Ecosystems at La Trobe University, and has more than 25 years' experience working on the ecology and hydrology of rivers and streams.

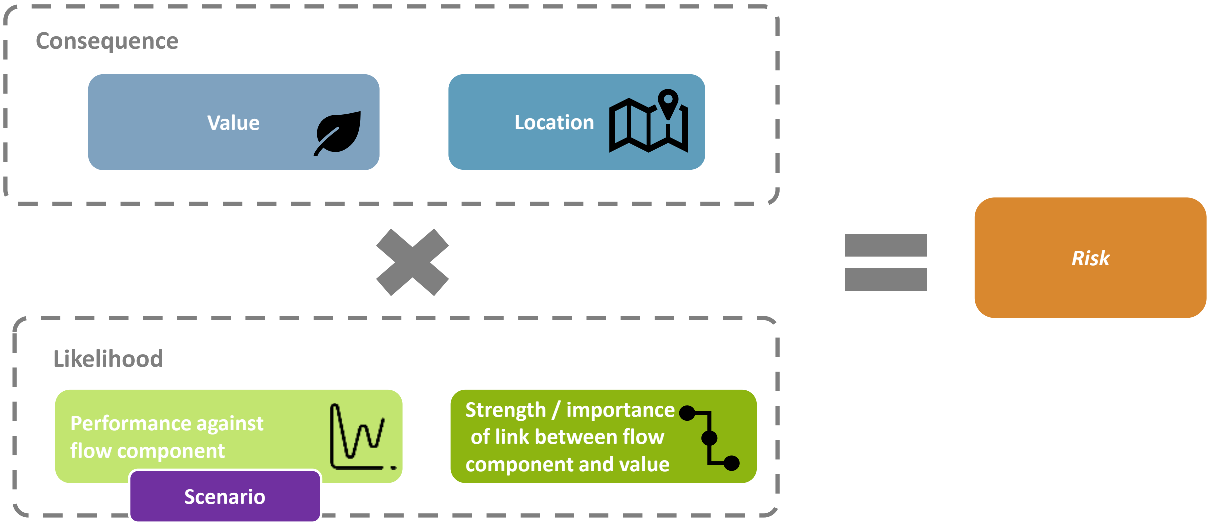


Figure 9. *Conceptual risk framework*

Figure 10 shows an overview of the Latrobe River system. The risk assessment has been limited to reaches 4, 6 and 8 comprising the Tanjil River the Latrobe River near Rosedale, and the Latrobe Estuary, downstream from the Thomson River confluence. The reach locations were selected for the risk assessment by the Technical Working Group as part of project scoping. These locations were confirmed by the project team and risk panel in discussion with DEECA and the WGCMA. Appendix A2 (Table 25) outlines these reaches and the rationale for inclusion in the risk assessment.

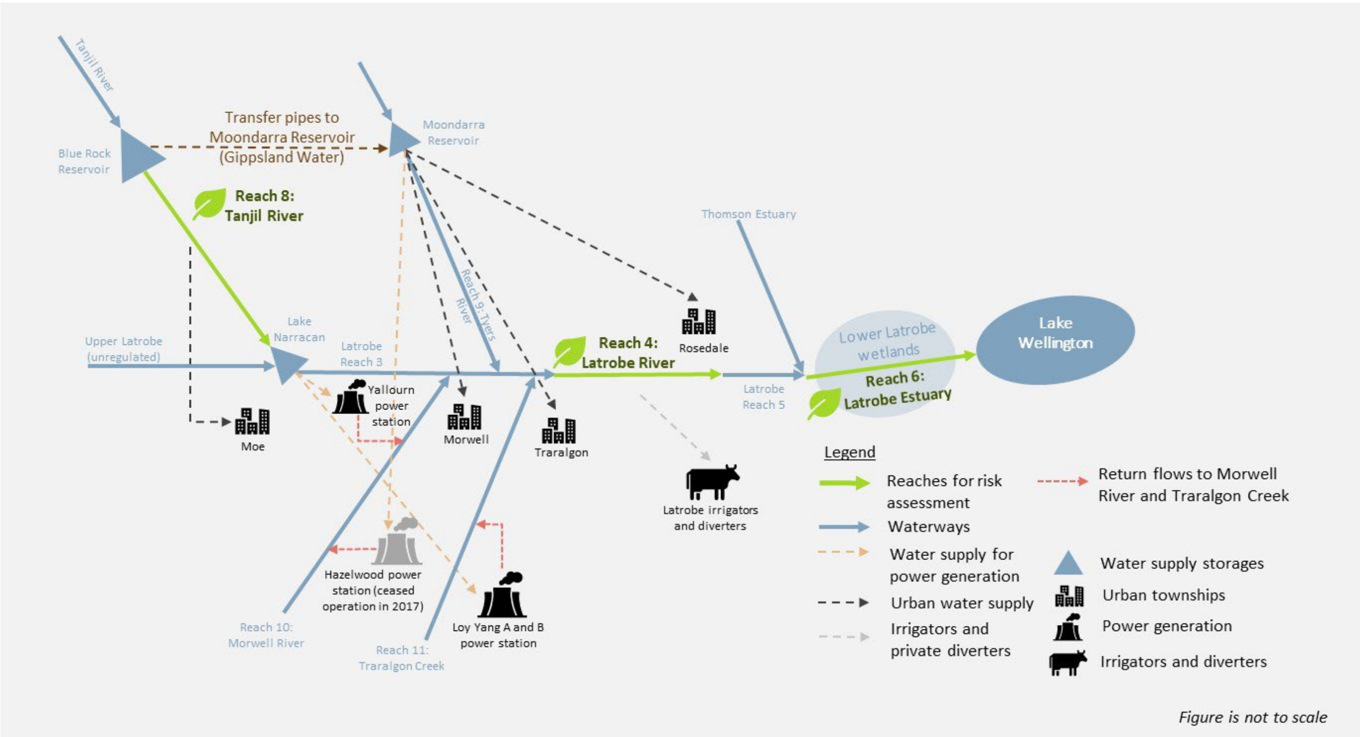


Figure 10. *Overview of Latrobe system*

The Lower Latrobe Wetlands are not specifically included in the risk assessment, but rather are represented in the flows in the estuary that support wetland watering. In this assessment, it is assumed that wetland watering infrastructure improvements are implemented to allow efficient delivery of the wetland watering requirements with the estuary flow conditions. The required wetland infrastructure improvements are included in Action 8-17 of the Central and Gippsland Region SWS. Wetland drawdown is not captured in this approach, but it is unlikely to be impacted by the scenarios.

Environmental values

The Latrobe system supports a diversity of ecosystems that sustains a large variety of plants and animal species of high conservation significance. It is also an essential source of freshwater that feeds into the Latrobe Estuary and extends through to the Ramsar-listed Gippsland Lakes including the Lower Latrobe Wetlands of Sale Common, Heart Morass and Dowd Morass and then to Lake Wellington.

The Latrobe environmental water requirements investigation (Alluvium 2020) identified a set of environmental values and their objectives that represent the values that society seeks to improve or maintain with water for the environment. This set of environmental values was adopted for the risk assessment along with any additional values identified in the Latrobe Ecological Effects Assessment (Hale et. al. 2020). The environmental values adopted for the risk assessment are Fish, Birds, Frogs, Turtles, Aquatic mammals, Submerged & Emergent Vegetation, and Riparian & Floodplain vegetation. Some example species and groupings within these values are shown in Figure 11.

It is important to note that the risk assessment does not examine the importance of individual species, rather it considers the broader significance of these species and how they represent the Latrobe system's most important environmental values and likely impact they may experience as a whole ecosystem. Other values identified in Alluvium (2020) such as water quality, macroinvertebrates, and geomorphology, are not explicitly included in the risk assessment as they are supporting the seven core environmental values. Instead, these supporting values are captured through flow components that support the values, for example, maintaining or improving water quality (e.g. dissolved oxygen concentration) in riverine pools is linked to the maintenance and improvement of fish values.

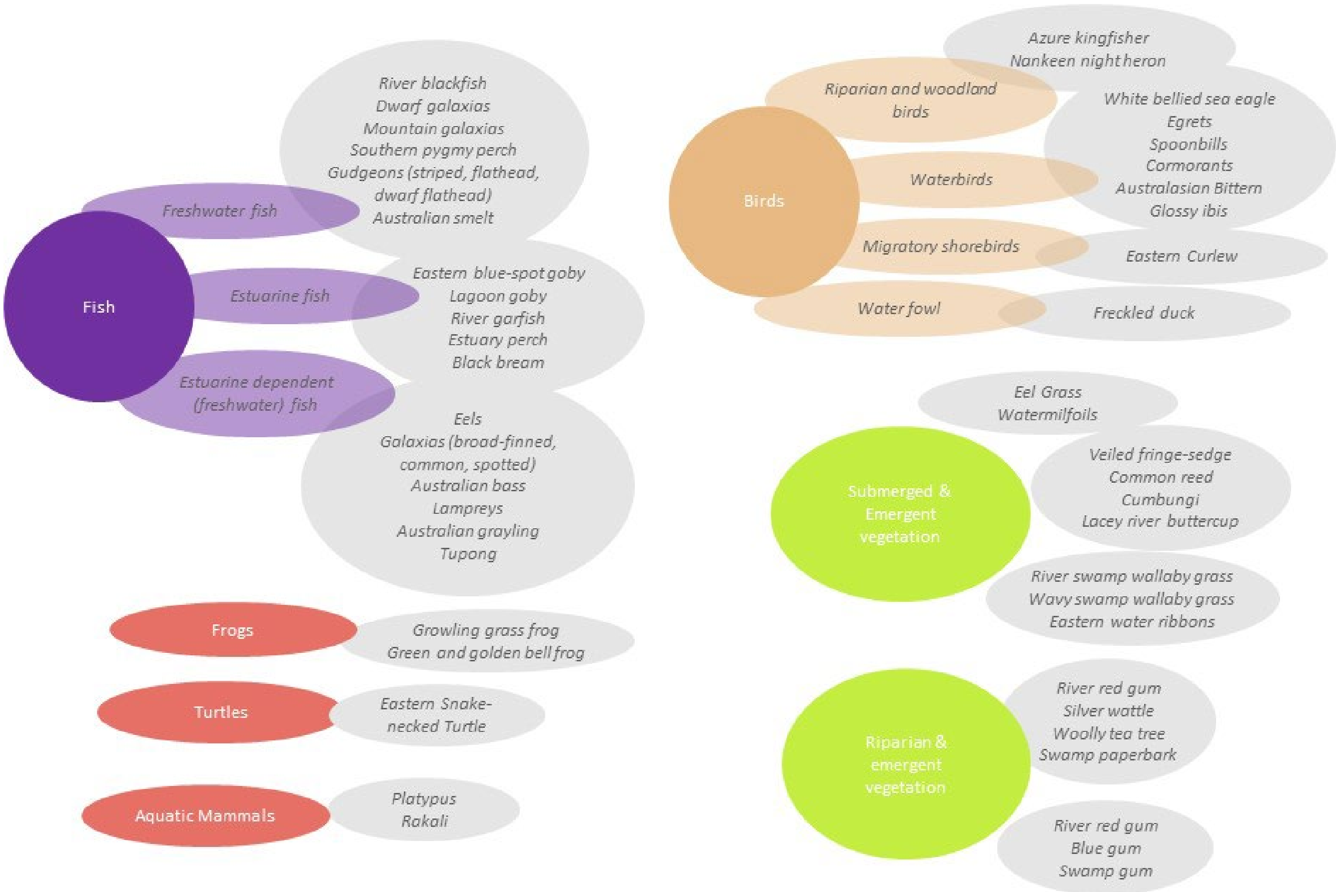


Figure 11. *Environmental values identified by Environmental Flows Technical Panel (adapted from Alluvium 2020)*

Traditional Owner values

For Traditional Owners, water is part of the fabric that is Country—without water there is no life. Water supports plants and animals, the people, is a place for gathering, and is a place for spiritual and cultural connection. For Gippsland's Traditional Owners, all of Gunaikurnai Country is connected with no separation between landscapes, waterways, coasts and oceans, and natural and cultural resources. From the Gunaikurnai perspective, water for the Latrobe Valley requires considering the upper catchments, the Latrobe River system, the Lower Latrobe Wetlands, and ultimately, through to the Gippsland Lakes.

Protecting and managing water is a custodial and intergenerational responsibility for the Gunaikurnai people. Cultural and spiritual values for water includes providing for the plants and animals important to Traditional Owners, drinking water, meeting places, language, song lines, stories, sacred places, customary use and recreational use. Water is also important for commercial activities traditionally through travel and trade, and to provide for economic development.

Traditional Owner values for the Latrobe system have been provided by GLaWAC for the purpose of this risk assessment. The following values have been adopted from the National Cultural Flows Research Project.

In addition to these values, GLaWAC have identified supporting uses (Figure 12). It is important to note that these cultural values and supporting uses cover a range of economic, social and environmental values, and they are supported by both the flow components discussed below and also the security of water entitlements. Refer to Appendix A4 for the relationship between these uses and values with flow components and security of entitlements.

Table 11. Traditional Owner values (Source: MLDRIN, NBAN & NAILSMA 2016)

Values	Description
Affective values	Qualities of the resource that sustain important affective qualities, such as aesthetic appreciation, ambience, inspiration, sensory responses, ecological appreciation, spiritual realisation and cultural well-being.
Custodial values	Moral or cultural obligations for the care of the landscape for present and future generations. Custodial values include values associated with bequest, future options and the transmission of knowledge and learning
Future use values	Including commercial or enterprise development aspirations
Identity values	Cultural sites or features of the resource that contribute to self or group identification
Place-based values	Cultural Places that are dependent upon the resource that are significant or valuable for their existence.
Practice – based values	Cultural Qualities of the resource or locations that is necessary to support personally, socially or culturally important practices, such as recreational use, resource harvest or religious and ceremonial practices.
Relational values	Contributions of a cultural site or feature of the resource that sustains, represents or embodies a relationship to historical or spiritual connection with the landscape, identity, genealogy, law and custom as a whole.
Social cohesion	Cultural Sites or qualities of the resource that contribute to community connectedness, social interaction, trust, inclusion, sense of belonging and the reduction of conflict within a community.
Well-being values	The cultural qualities of the resource or locations that contribute to physical and mental health, therapeutic activity, cultural well-being and quality of life.

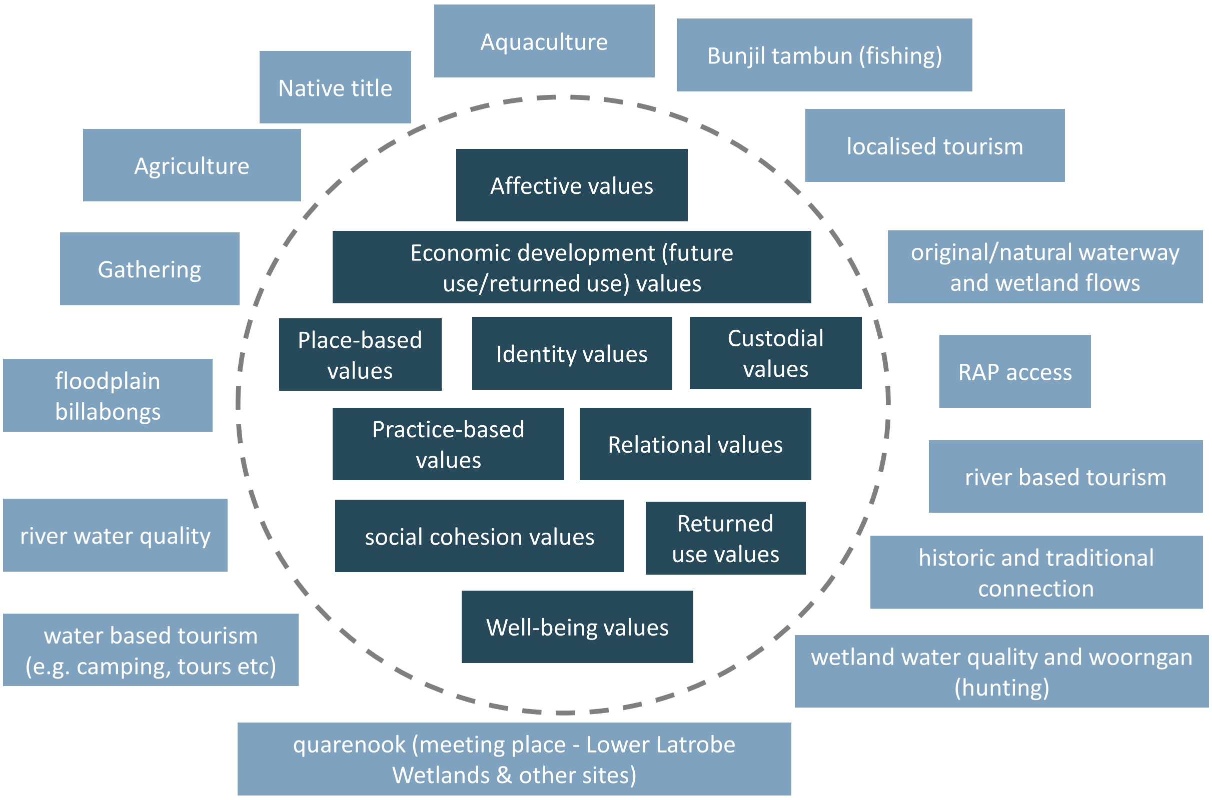


Figure 12. *Traditional Owner values (values provided by GLaWAC)*

Flow components

Flow components are specific flow ranges within a natural hydrograph that describes a system's flow regime. Each flow component provides a range of benefits for different parts of the riparian ecosystems and can be quantified hydrologically to determine the linkages between flows in river system and riparian environmental values. The Latrobe environmental water requirements investigation (Alluvium 2020) identified several flow components critical for the reaches of the Latrobe River, as illustrated in the notional hydrograph in Figure 13. These flow components are described below in Table 12.

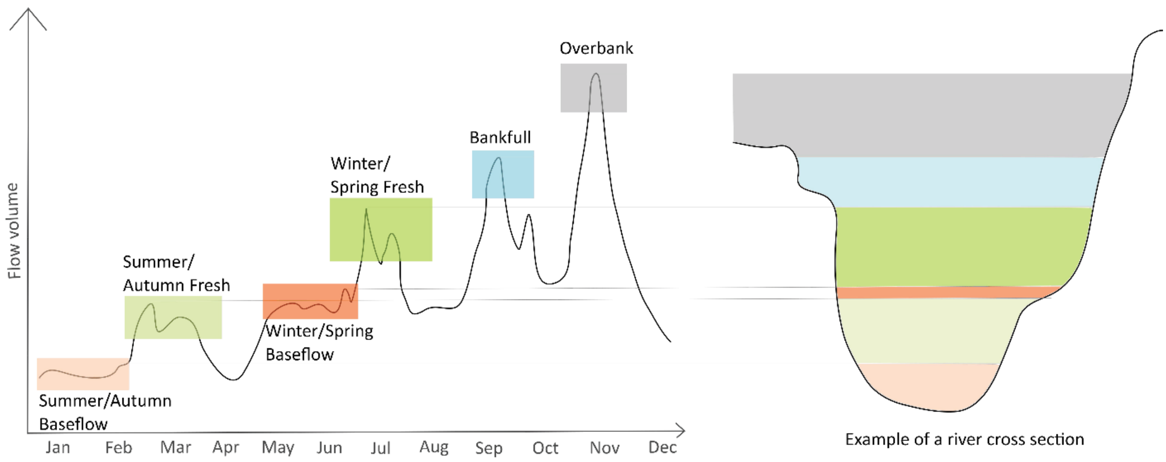


Figure 13. *Notional hydrograph showing commonly used terms to describe the flow regime in studies developing Environmental water requirements (Adapted from Victorian Environmental Water Holder https://www.vewh.vic.gov.au/water-for-the-environment/what-is-water-for-the-environment)*

Table 12. Hydrological description of flow components in the Latrobe system

Flow component	Description	Role and function of flow components in waterway
Summer / Autumn baseflows	Summer/autumn baseflows are the natural dry period (summer/autumn) flows or 'baseflows' that maintain water flowing through the channel, keeping in-stream habitats wet and pools full. These flows can occur after prolonged periods without rain and can be replenished by sub-surface flows and groundwater feeding into the channel.	▪ Maintain habitat area and water quality including pools and refuges ▪ Support submerged & emergent vegetation and limit terrestrial vegetation encroachment
Winter / Spring baseflows	Winter/spring baseflows refer to the persistent increase in low or base flow that occurs with the onset of the wet period. It is usually naturally similar or higher than summer/autumn baseflows	▪ Flushing sediments from pools, maintaining physical habitat features (e.g. benches)
Summer / Autumn Freshes	Summer/autumn freshes are frequent, small, and short duration flow events that exceeds the underlying baseflows. It can last for one to several days as a result of localised rainfall during the low flow period.	▪ Flush sediments from pools and maintain water quality ▪ Inundating benches to support growth of emergent macrophyte, sustain macroinvertebrates and zooplankton communities and increase breeding substrate for Blackfish. ▪ increase longitudinal connectivity for aquatic mammals, migratory fish, and estuarine residents across reaches
Winter / Spring Freshes	High flow freshes refer to sustained increases in flow during the high flow period as a result of sustained or heavy rainfall events. This flow usually occurs within the channel but not large enough to provide bankfull flows.	▪ provide food source, habitat, and migration cues for resident fish (in rivers and estuaries), turtles and frogs. ▪ Inundate higher benches to improve habitat quality for riparian vegetation and activate ecological processes to increase habitat for macroinvertebrates and zooplankton.
Bankfull Flows (any time of year)	Bankfull flows are large in-channel flows that fill the channel, but do not spill onto the floodplain.	▪ Maintain channel shape and form over longer time scales. ▪ Inundates riparian vegetation and disturbs emergent vegetation ▪ Nesting conditions for turtles
Overbank Flows (any time of year)	Overbank flows are higher and less frequent than bankfull flows and spill out of the channel onto the floodplain.	▪ Moisture for floodplain vegetation and stimulate macroinvertebrate and zooplankton production. ▪ Promote sediment deposition, carbon exchange, and organic matter supply between waterway and floodplain

7 Risk assessment findings

7.1 Overview of findings

Finding 1: The impact of the baseline (existing) conditions on environmental and Traditional Owner values in the Latrobe system is High.

Under existing conditions, the flow regime is significantly impacted by water users in the system, including power generation, urban water use, other industrial use and irrigation. This aligns with previous assessments of the water available to support environmental values, including the Latrobe Environmental Water Requirements Investigation (Alluvium 2020).

Environmental values where there are High or Significant risks under the baseline scenario are:

- Vegetation (submerged & emergent, riparian & floodplain), fish and birds in the estuary and Lower Latrobe Wetlands
- Fish and aquatic mammals in the Latrobe River (reach 4)
- Fish, aquatic mammals, and riparian and floodplain vegetation in the Tanjil River.

There are many Traditional Owner values where there are High or Significant risks under the baseline scenario, including the following Traditional Owner values: agriculture, aquaculture, Bunjil tambun (fishing), floodplain billabongs, gathering, historical and traditional connection, localised tourism, Native title, original/natural waterway and wetland flows, quarenook (meeting place - Lower Latrobe Wetlands), quarenook (meeting place - other sites), RAP access, river based tourism, river water quality, water based tourism (e.g. camping, tours etc), wetland based tourism, wetland water quality and woorngan (hunting).

The baseline may also pose a risk to the following core Traditional Owner values: affective, custodial, economic development (future use/returned use), identity, place-based, practice-based, relational, returned use, social cohesion, and well-being values.

Finding 2: Increasing the level of water take relative to the net historical take under the baseline, without other conditions being imposed, will materially increase the risk to environmental and Traditional Owner values.

Increasing the level of water take to full uptake (Scenario 1) significantly increases the risk to environmental and Traditional Owner values, including through reduced critical flows during the summer/autumn period in the Latrobe River and estuary. Reduced annual take was considered in some scenarios to ensure the impact of diversions on the volume of the Environmental Water Reserve is no more than current.

Gross historical take, with conditions in place (Scenario 5) increases the risks to some environmental values in the Tanjil River (e.g. a reduction in Bankfull flows), and there is no change in the risk in the Latrobe River and estuary associated with the level of take.

Other changes associated with conditions common to Scenario 3 (net take during winter/spring) and 4 (net take during winter/spring with annual cap) may occur as discussed further below. When the level of take is maintained at net historical levels, without any conditions imposed (Scenario 2), there is no change in risk to environmental and Traditional Owner values relative to the baseline.

In summary, managing the level of take is an important tool to avoid an increase in the risks to environmental and Traditional Owner values.

Finding 3: Conditions on the timing of water take, unregulated flow limits, and an annual cap on Blue Rock Reservoir releases decrease risks to environmental and Traditional Owner values.

The conditions imposed in Scenario 3 (net take during winter/spring), 4 (net take during winter/spring with annual cap) and 5 (gross take with all conditions) protect ecologically important flows in the summer/autumn period through the Latrobe River and estuary, reducing some risks to fish, aquatic mammals, vegetation and birds. However, these flows are just one part of the overall flow regime in this system and under these scenarios, the risk is still Significant to High (no change from the risk under the baseline).

Therefore, by imposing the conditions on the timing of water take, unregulated flow limits, and an annual cap on Blue Rock Reservoir releases, the risk to some environmental and Traditional Owner values may be reduced.

Finding 4: A future drier climate will materially increase the risk to environmental and Traditional Owner values under all scenarios.
The risk to environmental values and Traditional Owner values will increase under medium and high climate change conditions. Under a future drier climate and reduced water availability, the conditions on access to water for mine rehabilitation cannot be expected to produce the same level of increase or decrease in risk to Latrobe River environmental and Traditional Owner values as has been assessed for the current situation. This highlights the need for ongoing adaptive management as part of the broader Latrobe Valley transition and adaptation to a changing climate.

7.2 Risk to environmental values under baseline

Finding 1: The impact of the baseline (existing) conditions on environmental and Traditional Owner values in the Latrobe system is High.

The baseline risk assessment is summarised in Table 13. The risk assessment results for the baseline show the High risk (impact) for environmental values including Vegetation, Fish, Birds and Aquatic Mammals. The risk under the baseline for Frogs and Turtles is Medium risk (impact). The detailed risk assessment component and rationale for these classifications can be found in Appendix A3, and A4 – two examples are also provided here.

Baseline risk example – Frogs in the estuary and Lower Latrobe Wetlands:

- Frogs in the estuary and Lower Latrobe Wetlands have a consequence rating of **Moderate** as there are species of State / National significance, but there are only considered critical to reach/area (rather than the whole Latrobe systems or state)
- The flow components that support frogs (winter/spring freshes and bankfull flows) are very important (strong relationship between these flows and Frogs) and have good performance for the baseline, which means that the likelihood is **Possible**
- Combining the consequence (moderate) and likelihood (Possible) ratings results in a risk rating of **Medium**.

Baseline risk example – Fish in the Latrobe River (Reach 4):

- Fish in the Latrobe River have a consequence rating of **Major** as there are species of National Significance, and this reach is considered critical for the overall population in the Latrobe River.
- There are a range of flow components that support Fish that are important (strong relationship between these flows and Frogs) – under the baseline, summer-autumn freshes have the lowest performance, which means the likelihood rating that the hydrological regime impacts the values is Likely.
- Combining the consequence (Major) and likelihood ratings (Likely), results in a risk rating of **High**.

For the risk assessment, the baseline is a modelled representation of the current water use in the system and degree of hydrological modification. Applying the risk assessment framework to the baseline demonstrates the level of impact that this hydrological modification is having on environmental values.

The full table of risk results is provided below. The many High and Significant risk ratings reflect the water resource management of the Latrobe system, where there are large volumes of water extracted for power generation, urban supply, agriculture and other industrial uses. The High and Significant ratings in the estuary reflect the catchment impacts, but also the impacts of the opening to the ocean at Lakes Entrance which means freshwater is required to constantly push back the salt wedge in the Latrobe estuary and to maintain the environmental condition in the Lower Latrobe Wetlands and the estuary.

This overall finding aligns with findings from previous studies undertaken for the LVRRS (Ecological Effects Study (Hale et al. 2020) and Environmental Water Requirements Investigation (Alluvium 2020)). The index of Stream Condition assessed the Latrobe River in the study area as ranging from Poor to Very Poor condition, with low scores across all categories, particularly for hydrology. The recent Central and Gippsland Region SWS noted that the Latrobe River and estuary have an environmental water deficit of 129 GL/year and additional water is urgently needed to maintain water quality and habitat, and to support drought refuges.

The changes to return flows from power generation in the Morwell River and Traralgon Creek may increase the risk to environmental values in these reaches. As this influence of return flows applies to all of the mine rehabilitation scenarios, these reaches were not the subject of the risk assessment. The potential impacts of ceasing return flows on the environmental values in these reaches is documented in the Latrobe Environmental Water Requirements Investigation and the Environmental Effects study (Alluvium 2020; Hale et. al. 2020). While these return flows are not natural parts of the flow regime, they may provide some benefits to environmental values. Ceasing return flows impacts on baseflows and freshes in the system year-round, with the biggest impact relative to current in the summer/autumn period (Alluvium 2020).

Table 13. Baseline risk assessment

	Environmental value	Maximum risk under Baseline	Relevant flow components for risk ratings Significant or High
Latrobe River (Reach 4)	Vegetation – submerged & emergent	Medium	-
	Vegetation – riparian & floodplain	Medium	-
	Fish	High	Summer/autumn Fresh 1 (Water quality)
	Birds	Low	-
	Aquatic mammals	High	Summer/autumn Fresh 1 (Water quality)
	Frogs	Medium	-
	Turtles	Medium	-
Latrobe Estuary & wetlands	Vegetation – submerged & emergent	High	Summer/autumn Fresh 1
	Vegetation – riparian & floodplain	Significant	Winter/spring Fresh 1, Bankfull
	Fish	High	Summer/autumn Fresh 1
	Birds	High	Summer/autumn Fresh 1
	Frogs	Medium	-
	Turtles	Medium	-
Tanjil River	Vegetation – submerged & emergent	Medium	-
	Vegetation – riparian & floodplain	Significant	Overbank flows
	Fish	Significant	Winter/spring baseflow
	Birds	Medium	-
	Aquatic mammals	Significant	Winter/spring baseflow
	Frogs	Medium	-
	Turtles	Medium	-

7.3 Summary of changes in performance with the environmental flow recommendations

As described in Section 6, changes in the risk assessment ratings between scenarios are driven by changes in performance ratings. Table 14 below provides the performance scores for the baseline and each scenario across the three locations in the Latrobe system and range of flow components. Changes to performance scores relative to the baseline are shown in brackets – only changes greater than +/-5% are highlighted, as this is deemed material by the risk panel. Any changes in performance rating associated with material changes in score relative to the baseline are also shown in the table. Note that where there is a change in performance rating (e.g. from Medium-Low to Medium-High performance) resulting from a change in performance score of less than 5%, this is not highlighted as a change as it is just a function of the thresholds set for the performance ratings.

The following sections (Sections 7.4 -7.6) explore the changes in performance and risk associated with the different scenarios and conditions.

Table 14. Annual average performance scores against flow recommendations, post-1975 historic climate reference period (post 1975 to 2020). Changes from baseline greater than 5% shown in brackets. The performance ratings are described in Appendix A1. Refer to Section 6 above for a system map - Figure 10 on page 30.

Location	Flow component	Baseline		Scenario number (performance score)					
		Score	Rating	1	2	3	4	5	Change to performance rating*
Latrobe River (Reach 4 - Scarnes Bridge to Kilmany South)	Summer / Autumn Baseflow	97%	High	96%	96%	96%	96%	96%	No change.
	Summer / Autumn Fresh 1	62%	Medium-Low	55% (↓7%)	64%	74% (↑12%)	74% (↑12%)	72% (↑10%)	Scenario 1 decreases to Low performance
	Summer / Autumn Fresh 2	83%	Medium-High	78% (↓5%)	84%	91% (↑8%)	91% (↑8%)	90% (↑7%)	Scenarios 3, 4 and 5 increase to High performance
	Winter / Spring Baseflow	68%	Medium-Low	62%(↓6%)	68%	69%	69%	68%	No change.
	Winter / Spring Fresh	95%	High	95%	95%	95%	95%	95%	No change
	Bankfull	79%	Medium-High	77%	79%	78%	78%	77%	No change.
	Overbank	86%	High	84%	86%	85%	85%	84%	No change.
Latrobe River Estuary	Summer / Autumn Baseflow	65%	Medium-Low	59% (↓7%)	62%	67%	68%	67%	Scenario 1 decreases to Low performance
	Summer / Autumn Fresh 1	58%	Low	53% (↓5%)	58%	64% (↑6%)	64% (↑6%)	64% (↑6%)	Scenarios 3, 4 and 5 increase to Medium-Low performance
	Summer / Autumn Fresh 2	62%	Medium-Low	56% (↓5%)	62%	66% (↑5%)	66% (↑5%)	65% (↑5%)	Scenario 1 decreases to Low performance
	Winter / Spring Baseflow	91%	High	87%	91%	93%	93%	93%	No change.
	Winter / Spring Fresh 1	81%	Medium-High	79%	81%	82%	82%	81%	No change.
	Winter / Spring Fresh 2	76%	Medium-High	71%	76%	73%	73%	72%	No change.
	Bankfull	79%	Medium-High	76%	80%	78%	78%	76%	No change.
	Overbank	91%	High	89%	91%	90%	90%	89%	No change.
Tanjil River (Reach 8)	Summer / Autumn Baseflow	98%	High	98%	98%	98%	98%	98%	No change
	Summer / Autumn Fresh	98%	High	96%	98%	95%	96%	94%	No change
	Winter / Spring Baseflow	52%	Low	45% (↓7%)	54%	83%(↑31%)	82%(↑29%)	77%(↑24%)	Scenarios 3, 4 and 5 increase to Medium-High performance
	Winter / Spring Fresh	83%	Medium-High	77% (↓6%)	84%	78%(↓6%)	78% (↓6%)	77% (↓6%)	No change.
	Bankfull	70%	Medium-Low	59% (↓11%)	70%	67%	67%	58% (↓12%)	Scenario 1, 5 decrease to Low performance
	Overbank	48%	Low	41% (↓7%)	48%	46%	46%	41% (↓7%)	No change.

*Changes in rating only identified where the change results from significant change in performance score(i.e. +/- 5%)

7.4 Change in risk associated with level of water take

Finding 2: Increasing the level of take relative to the net historical take under the baseline, without other conditions, materially increases the risk to environmental and Traditional Owner values.

Finding 2A: Scenario 1 (full uptake, no conditions) materially increases the risk to environmental values in the Latrobe system relative to the baseline scenario under post-1975 historic climate reference period conditions.

Finding 2B: Scenario 2 (net take, no other conditions) does not materially change (i.e. increase or decrease) the risk to environmental values and Traditional Owner values relative to the Baseline scenario for the Latrobe system under the post1975 historic climate reference period conditions.

Finding 2C: Scenario 5 (gross historical take, with conditions) decreases some risks and increases other risks to environmental values in the Tanjil River relative to the baseline and to Scenario 3 or 4 under the post-1975 historic climate reference period conditions. Scenario 5 increases risks to environmental values in the Tanjil River relative to Scenario 3 or 4 under the post-1975 historic climate reference period conditions.

Finding 2D: Scenario 5 (gross historical take, with conditions) does not change (i.e. increase or decrease) the risk to environmental values in the Latrobe River and estuary relative to the baseline, Scenario 3 or 4 in the Latrobe River and estuary under the post-1975 historic climate reference period conditions.

Three different overall levels of water take were tested in the scenarios:

- Scenarios 2, 3,and 4 include net historical take of 39.0 GL/year, which is equivalent to the baseline net take once return flows are considered
- Scenario 5 includes gross historical take of 62.8 GL/year, which is the same demand as the Baseline, but without return flows from Yallourn and Loy Yang power stations
- Scenario 1 includes full uptake gross historical take of 96.5 GL/year.

Scenario 2 (net take, no other conditions) results in very similar flows as the baseline (Figure 14), and unsurprisingly the change in performance scores between Scenario 2 and the baseline across all locations and parts of the flow regime is not material (less than +/-5%). Scenarios 3 and 4 include additional conditions that are further discussed in section 7.5 below.

Scenario 5 shows an improvement in winter-spring baseflows, but reduced performance in achieving **winter-spring freshes, bankfull and overbank** flows compared to the baseline **in the Tanjil River.** The decreased performance with respect to bankfull flows (and therefore increase in risk) occurs relative to the baseline, and also relative to Scenario 3 and 4, which have the similar conditions to Scenario 5, except for the maximum level of take. There is no change in risk to environmental values in the Latrobe River and estuary associated with the level of take. Other changes associated with conditions common to Scenario 3, 4 and 5 are discussed further below (Section 7.5).

For Scenario 1 (full uptake, no conditions), there is a significant reduction in **summer-autumn freshes** in the Latrobe River (Reach 4) and estuary, plus **summer-autumn baseflows** in the estuary. The reduction in median daily flows under Scenario 1 is shown in Figure 14 for the Latrobe River Scenario 1 also shows reduced flows relative to the Baseline for **bankfull flows in the Tanjil River** (refer discussion below and Table 14 in section 7.3).

The main differences in the scenarios based on the level of take are discussed further below.

How to read this graph

This graph demonstrates the natural variability in the flow regime over the year and the difference between scenarios in these different seasons. To generate the graph, the modelled flow from all years at a given location for a given day of the year is summarised by taking the **median (50th percentile) value.** Thus, for all the years in the record, 50% of modelled flows are less than the median flow for that day and 50% are over the median flow for that day.

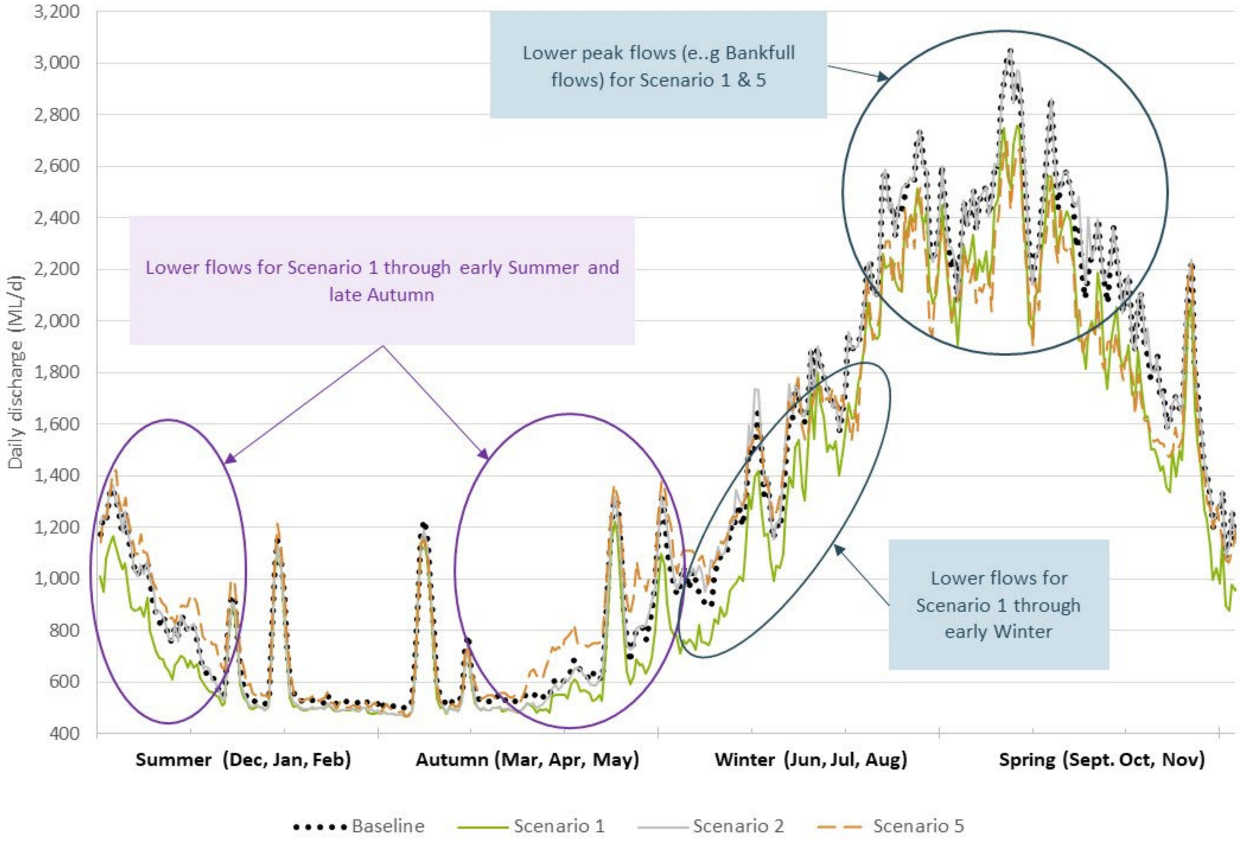


Figure 14. *Median flow (discharge) per day of the year across baseline [modelled data under post-1975 historic climate reference period conditions], Scenario 1 (full uptake, no conditions), Scenario 2 (net historical, no conditions) and Scenario 5 (gross historical, with conditions) for Latrobe River reach 4.*

Impacts on the Latrobe River and estuary baseflows and Summer/ Autumn freshes

The full uptake conditions included in Scenario 1 result in a significant decrease in performance for baseflows all year and for summer-autumn freshes through the Latrobe River and estuary (5-7% decrease - refer Table 14 in Section 7.3Table 33). This results in a change from Medium-Low to Low performance for the following flow components:

- Latrobe River reach 4 summer-autumn fresh 1 (water quality)
- Latrobe River estuary summer-autumn baseflow
- Latrobe River estuary summer-autumn fresh 2.

Therefore, there is an increased risk to environmental and Traditional Owner values under Scenario 1. Summer/autumn baseflows and freshes are critical for:

- Providing bench inundation which is important for the growth of emergent macrophyte vegetation and sustain macroinvertebrate and zooplankton
- Flushing of pools to maintain water quality and transport sediment through the system which maintains pool habitat for instream fauna (fish, aquatic mammals, frogs)
- Longitudinal connectivity for movement of aquatic mammals and fish
- Partial flushing the estuary to allow for wetland watering (through infrastructure).

Impacts on the Tanjil River bankfull flows

There is a material decrease in performance (>5%) for bankfull flows in the Tanjil River under Scenario 1 (full uptake, no conditions) and Scenario 5 (Gross historical take, with conditions) (11-12% decrease - refer Table 14 in Section 7.3 Table 33), which results in a change from Medium-Low Performance to Low Performance. This increases the risk to Riparian Vegetation values from bankfull flows from Medium to Significant.

This may be in part due to reduced annual frequency and volume of spills from Blue Rock Reservoir compared with the baseline for all scenarios except for Scenario 2 (net historical take, no other conditions). The reduced spills can be associated with an increase in annual take compared to the baseline (Scenario 1 and 5) and or an increase in take during the winter/spring period (Scenarios 3, 4 and 5) when Blue Rock Reservoir typically spills under current arrangements.

Under Scenario 1, there are also a material decrease in performance for overbank, winter-spring baseflows and winter-spring freshes (5-7% decrease - refer Table 14 in section 7.3 Table 33), but no corresponding change in performance rating.

This increases the risk to environmental values, in particular riparian & floodplain Vegetation and Riparian zone birds. Floodplain inundation and bankfull flows are also important for many supporting values: stimulating macroinvertebrate and zooplankton production, the exchange of sediment (and nutrients), and carbon between waterway and floodplain to increase productivity, and maintaining channel capacity and bench habitat.

7.5 Change in risk associated with conditions on take

Finding 3: Conditions on the timing of water take, unregulated flow limits, and an annual limit on Blue Rock releases decrease the risks to environmental values.

Finding 3A: Scenario 3 (net take during winter/spring) and 4 (net take during winter/spring with annual cap) decreases the risk to environmental values and Traditional Owner values relative to the baseline scenario under the post-195 historic climate reference period.

Finding 3B: Scenario 4 does not materially change the risk to environmental values and Traditional Owner values relative to Scenario 3 under the post-1975 historic climate reference period.

Finding 3C: Scenario 5 (gross take during winter/spring with annual cap) decreases some risks and increases other risks to environmental values and Traditional Owner values relative to the Baseline scenario under the post-1975 historic climate reference period.

Scenarios 3, 4, and 5 all require that the water demands for mine rehabilitation are restricted to the winter-spring period (June-November) and that unregulated flow harvesting is restricted to higher flows only. Scenario 4 and 5 also include an annual limit on releases from Blue Rock Reservoir for mine rehabilitation (capped at 25th percentile release).

Restricting water take to the wettest months of the year (Jun-Nov) avoids summer-autumn take when the river is most flow stressed, and irrigator demand and competition for unregulated flow is highest. The threshold to prevent winter-spring baseflow from being diverted helps to protects ecologically important flows. Re-instating (with modification) limits on the annual releases from Blue Rock Reservoir is intended to protect the resilience of the Tanjil River system and share the risk of drying climate more equitably.

Scenarios 3,4 and 5 show an increase in performance for some flow components, including **Latrobe River summer-autumn Fresh 1 & 2** (see Figure 15), **Latrobe estuary summer-autumn Fresh 1**, and the **Tanjil River winter-spring baseflows**. The increased performance reduces the risk to environmental values under the post-1975 historic climate reference period, which is explored further below.

For Scenarios 3 and 4, there is no significant change in performance (and therefore risk) between these scenarios. The annual limit on releases from Blue Rock Reservoir introduced in Scenario 4 (and Scenario 5) will take effect in selected years only, typically drier years. The conditions work together as a package and have been modelled in a particular sequence to test the cumulative change in risk. If the conditions were tested in a different sequence, the incremental impact of each individual condition would be different.

While there are reduced risks to environmental values under Scenario 5 in the Latrobe River, with increased performance of winter-spring baseflows due to the conditions on the timing of take, unregulated flow limits, and an annual cap on Blue Rock Reservoir releases, it was also found that there were increased risks with decreased performance of some flow components, including bankfull flows, in the Tanjil River associated with the gross historical level of take.

How to read this graph

This graph demonstrates the natural variability in the flow regime over the year and the difference between scenarios in these different seasons. To generate the graph, the modelled flow from all years at a given location for a given day of the year is summarised by taking the **median (50th percentile).** So for all the years in the record, 50% of modelled are less than the median for that day and 50% are over the median for that day.

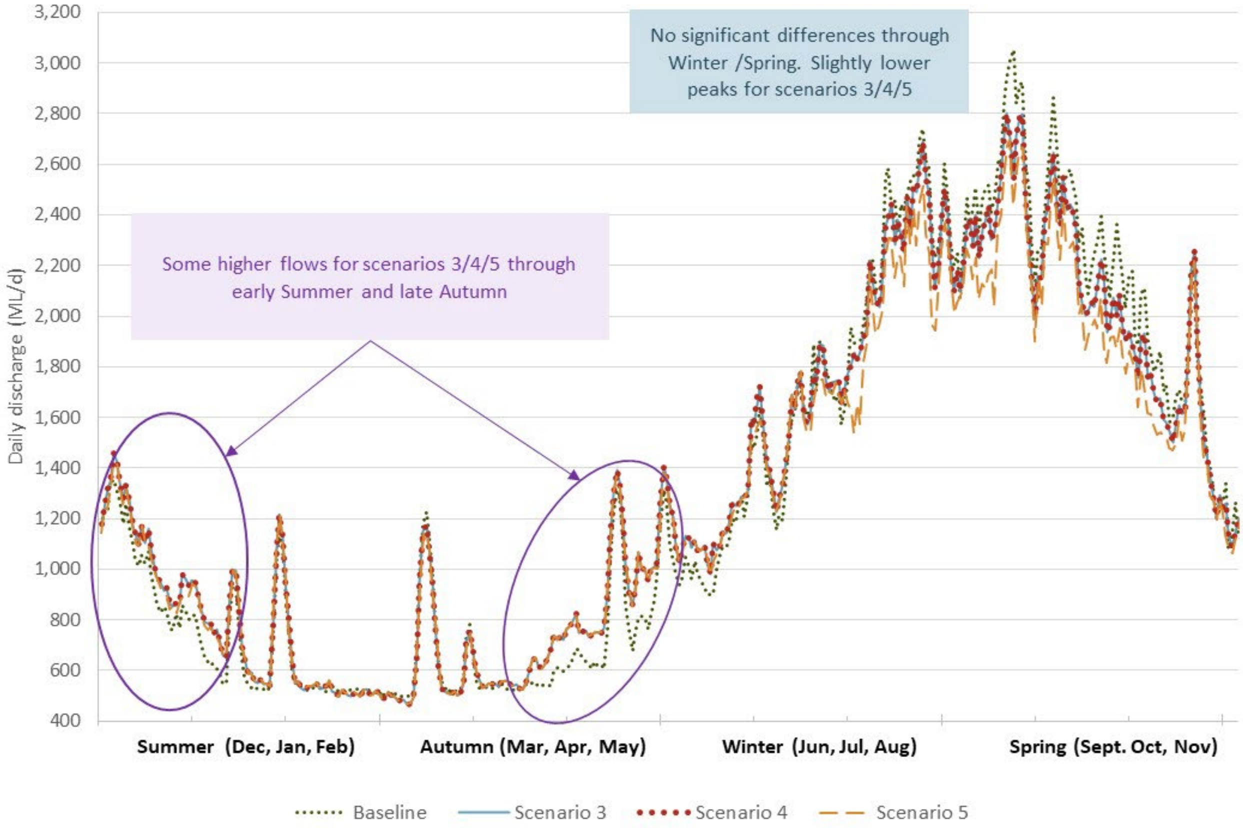


Figure 15. *Median flow (discharge) per day of the year across Baseline [modelled data under post-1975 historic climate reference period conditions], Scenario 3 (net historical take in winter/spring), 4 (net historical take with all conditions), and Scenario 5 (gross historical take with all conditions) for Latrobe River reach 4.*

Impacts on the Latrobe River summer-autumn freshes

The conditions included in Scenarios 3,4, and 5 result in a material increase (>5%) in performance for summer-autumn freshes in the Latrobe River (ranging from a 8 to 12% increase – refer Table 14 in section 7.3). This results in a change from Medium-High to High performance for summer-autumn fresh 2 (fish and vegetation) and reduces some risk to Fish, aquatic mammals, and vegetation. Summer-autumn fresh 1 (water quality) does not change the performance category.

Summer-autumn freshes are a priority for environmental water managers in the Latrobe River (refer Table 2 above). Improving the occurrence of summer-autumn freshes in the system reduces the risk to environmental values by maintaining essential habitat for fish (including Blackfish and Australian Grayling) and aquatic mammals. This is provided through the following processes and functions:

- Increased bench inundation which is important for the growth of emergent macrophyte vegetation and sustain macroinvertebrate and zooplankton populations
- Increased flushing of pools to maintain water quality and transport sediment through the system which maintains pool habitat for instream fauna (fish, aquatic mammals, frogs)
- Increased longitudinal connectivity for movement of aquatic mammals and fish.

However, the overall risk for the Latrobe River Reach 4 under these scenarios for Fish and aquatic mammals is still High.

While the above assessment demonstrates some improvement under the proposed conditions, the performance against summer-autumn fresh recommendations remains in the Medium-Low and Medium-High category (i.e. less than 85%, except for summer-autumn Fresh 1 in the Latrobe River Reach 4). Therefore, any additional water available for the environment that arises from implementation of the Central and Gippsland Region SWS would provide complementary benefits and help to better protect environmental values in the system.

Figure 16 provides an example summer-autumn period (in 1978), which shows higher magnitude peaks and longer durations for the freshes under Scenarios 3 and 4. Longer duration events are important for vegetation growth and for ensuring there is sufficient time for fish movement. Sufficient magnitude is important for ensuring flushing of sediment and turning over pools for water quality.

How to read this graph
A daily flow (discharge) graph, or hydrograph, represents the volume of water moving down a stream per unit of time. It is measured at a specified point, usually at a flow gauging station and is plotted as a line graph for interpretation. It can show the differences between scenarios for a given period (e.g. a season or year) but is often just one example, and does not represent the variability across all years.

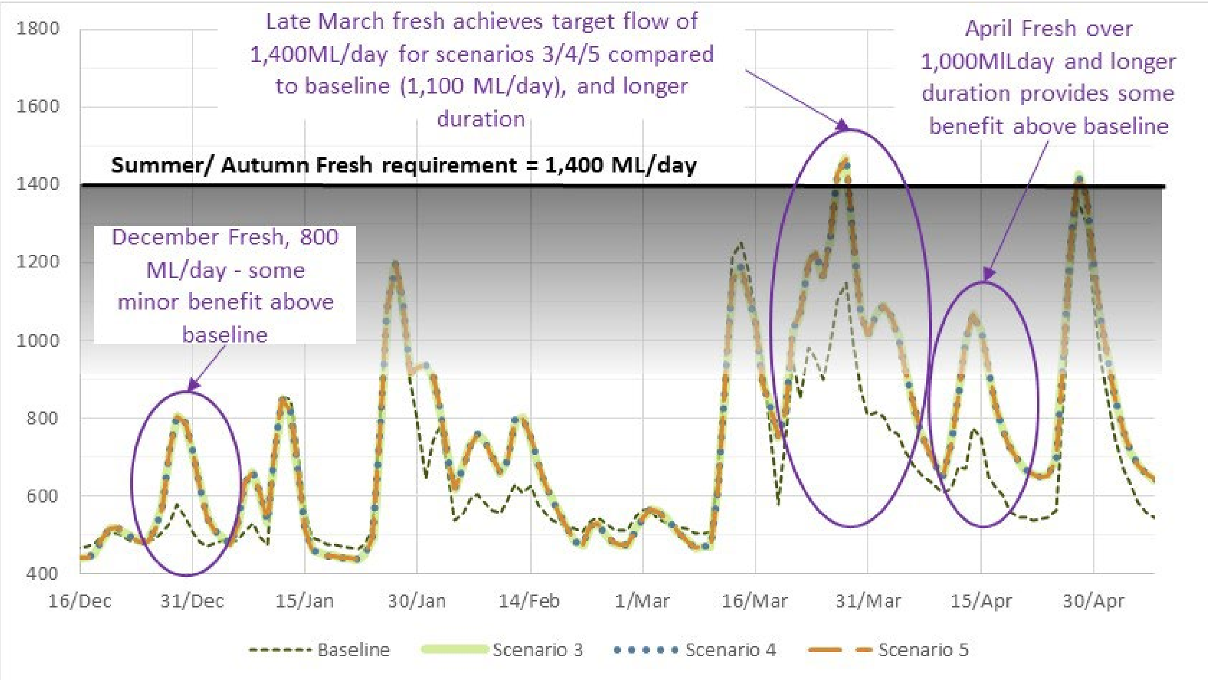


Figure 16. *Hydrograph of example summer-autumn period (Dec 1977 – April 1978) [modelled data under post-1975 historic climate reference period conditions], where there is a difference in freshes in the Latrobe River between the baseline and conditions included in Scenarios 3 (net historical take during winter/spring), 4 (net historical take with all conditions) and 5 (gross historical take with all conditions) that limit take for mine rehabilitation to the winter/spring period. Note: Scenario 3, 4, and 5 plot on top of each other in this graph.*

Impacts on the Latrobe estuary Summer/ Autumn freshes
Similar to the Latrobe River, there are improvements in performance in the Latrobe estuary for summer-autumn Fresh 1 and 2 (ranging from a 5-6% increase – refer Table 14 in section 7.3 Table 33), leading to an increase in performance category from Low to Medium-Low Performance and a reduction in risk to Fish and Birds from High to Significant.

The increased performance (and reduced risk) occurs because of more frequent (partial) flushing of the estuary which provides water for the Lower Latrobe Wetlands (through infrastructure), helping to maintain water quality in Heart Morass and Dowd Morass and support vegetation and waterbirds.

However, the overall risk for Latrobe estuary for Fish and vegetation is still High.

Impacts on the Tanjil River in the winter/spring period
Under Scenarios 3, 4, and 5 there is increased performance for winter-spring baseflows in the Tanjil River (24-31% increase - refer Table 14 in section 7.3). This increases the performance score from Low to Medium-High for winter-spring baseflows. There is also a decrease in performance for these scenarios for winter-spring freshes (6% decrease - refer Table 14 in section 7.3), but this does not result in a change to the performance rating. Overall, these changes reduce the risk to fish and aquatic mammals from Significant to Medium.

Figure 17 provides an example winter-spring period (in 1988), which shows higher baseflows through winter-spring under Scenarios 3, 4 and 5. The higher baseflows during winter are important for flushing sediment (e.g. sands) out of pools. This in turn supports macroinvertebrate populations and provision of pool habitat which is also critical for aquatic mammals (Platypus and rakali) and fish species. These higher flows in winter also provide greater depth of riffles to enable free movement throughout the reach for aquatic mammals (Platypus and rakali) and fish species.

Baseflows are important year-round for providing pool habitat (adequate depth), and to support migratory and resident freshwater fish, macroinvertebrates, aquatic mammals, turtles, and submerged vegetation. These flows also limit the encroachment of terrestrial vegetation, support emergent macrophyte vegetation and maintain dissolved oxygen levels in pools (water quality).

High flow impacts on the Tanjil River
Previous scenarios tested in the preliminary modelling stage included high flow harvesting (and associated releases from Blue Rock Reservoir) all year around, which lead to constant high flows during the summer-autumn period around 200 ML/day, which is significantly higher than under unimpacted or 'natural' conditions[23]. Constantly higher flows in the summer/autumn period may have impacts on submerged and emergent vegetation and bed and bank erosion, which then impacts on instream species (e.g. fish, platypus). The water access condition to restrict harvesting to the winter-spring period helps to ensure that there are not artificially higher flows in the Tanjil River during summer-autumn. Note that this does not get included in the performance assessment, but has been directly assessed by the Risk Panel.

Given this condition restricting take to the winter, constantly higher flows during the winter-spring period are observed for Scenarios 3, 4 and 5 (over 300 ML/day for Scenarios 3 and 4, and over 400 ML/day for Scenario 5). These flows are within the range of the unimpacted or 'natural' conditions[24]; that is, during the winter-spring period, these higher flows are not expected to pose a risk to environmental or Traditional Owner values.

During the winter-spring period, a relatively constant flow rate was observed for Scenarios 3-5, which is not desirable as some day-to-day variability provides more optimum conditions for biota. In practice, releases should incorporate day-to-day variability where possible and align with recommended ramp up and ramp down rates to prevent erosion issues.

[23] Alluvium 2020 shows that unimpacted flows in the Tanjil River during the Summer/ Autumn period range from 100 – 400 ML/day, with a median less than 200 ML/day
[24] Alluvium 2020 shows that unimpacted flows in the Tanjil River during the Winter/Spring period range from 200 – 1,000 ML/day, with a median of 400 ML/day

How to read this graph
A daily flow (discharge) graph, or hydrograph, represents the volume of water moving down a stream per unit of time. It is measured at a specified point, usually at a flow gauging station and is plotted as a line graph for interpretation. It can show the differences between scenarios for a given period (e.g. a season or year) but is often just one example, and does not represent the variability across all years.

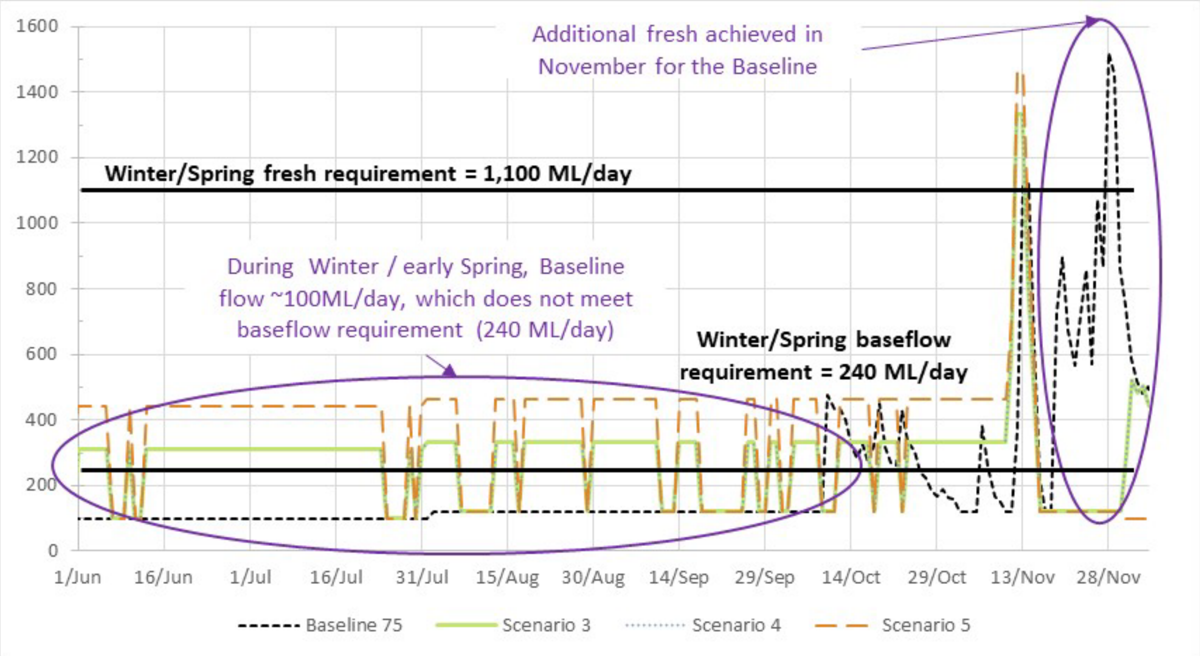


Figure 17. *Hydrograph of example winter-spring period (June – November 1988) [modelled data under post-1975 historic climate reference period conditions] in the Tanjil River where there is a difference between the baseline and conditions included in Scenarios 3/4/5 that limit take for mine rehabilitation to the winter-spring period. Note: Scenario 3 and 4 plot on top of each other in this graph.*

7.6 Changes under future climate change conditions

Finding 4: A future drier climate would result in a materially increased risk to environmental values under all scenarios.

Finding 4A: Under baseline conditions, a drier climate change would materially increase the risk to the environmental values in the Latrobe system.

Finding 4B: Under a future drier climate and reduced water availability, the conditions on access to water for mine rehabilitation cannot be expected to produce the same level of increase or decrease in risk to Latrobe River environmental values as has been assessed for the current situation. This highlights the need for adaptive management to ensure that any conditions introduced continue to reduce the impact on environmental values.

Three future climate scenarios have been run as a sensitivity analysis on the post-1975 historic climate reference period: 2065 Low, 2065 Medium, and 2065 High climate change. This risk assessment focused on the Medium and High scenarios, as these represent drier conditions and demonstrate the range of possible futures relative to the baseline under the post-1975 historic climate reference period (post 1975 – 2020).

It should be noted that the adoption of a 2065 timeframe the climate conditions is conservative in that the timeframes for transition away from coal-fired power generation are such that 2065 climate projections are likely most applicable only to the end-stages of mine rehabilitation. The 2065 climate conditions were purposely chosen to form a 'book end' on the range of likely climate impacts.

The potential changes in water availability under the 2065 climate change scenarios range from a 16% increase in runoff under the medium scenario to a 42% reduction in runoff under the High scenario. Latrobe River inflows are projected to be 350 GL/year lower on average under the 2065 high climate change scenario (relative to both current conditions and the year 2065 low climate change scenario), with much lower volumes held in storage, less frequent spills from storages, and lower reliability of supply to most water users.

These changes in water availability will present a challenge for water resource management in the Latrobe system and are likely to lead to declining waterway health. The Latrobe is a system in transition and balancing water resources and outcomes will be managed over this period through the ongoing review processes as part of the Sustainable Water Strategies, Long Term Water Resource Assessment and LVRRS. This includes the implementation of actions identified in the Central and Gippsland region SWS. While this is beyond the scope of the current risk assessment, it is critical that these other policy reviews are adequately supported with appropriate monitoring and modelling to ensure where appropriate key environmental values (and cultural values) can be protected.

A drier future climate materially increases the risk to environmental values for the baseline water management arrangements.

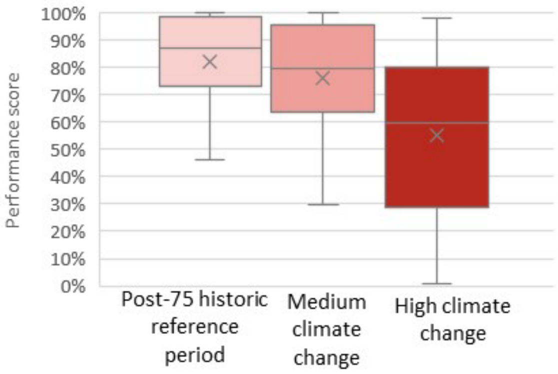
There are significant decreases in performance for the baseline under the 2065 Medium and High Climate change scenarios for the baseline. All flow components except one decrease performance by over 5%, with a mean decrease in performance across all flow components of 30% (refer full performance scores in Appendix B1). For the Latrobe River and estuary, all except two flow components are rated as Low Performance under the High climate change scenario.

For example, winter-spring freshes in the estuary show significant decrease in performance scores under Medium and High climate change scenarios (Figure 18). This results in a change in performance score from Medium-High performance to Low performance. These larger flows are important for pushing back the salt wedge to support growth of Phragmites in the lower estuary during spring, providing a salinity gradient for Grayling juveniles to migrate upstream from sea and providing for wetland watering which support a range of outcomes for bird, fish, frogs, macroinvertebrates and vegetation.

How to read this graph

A box plot consists of a 'box' and whiskers that extend either side of the box. The box contains 50% of the data. The central line represents the median (50th percentile), the top represents the 25th percentile (or 1st quartile) and the bottom the 75th percentile (or third quartile). The whiskers extend to the minimum and maximum value and the mean is illustrated as 'X' within the boxplot.

The below box plots represent the range of performance scores across all years modelled. The bigger the box, the bigger range of values that typically occur. When comparing between two scenarios, if the median (middle line), mean ('X'), or the overall box is positioned lower, it suggests poorer performance.



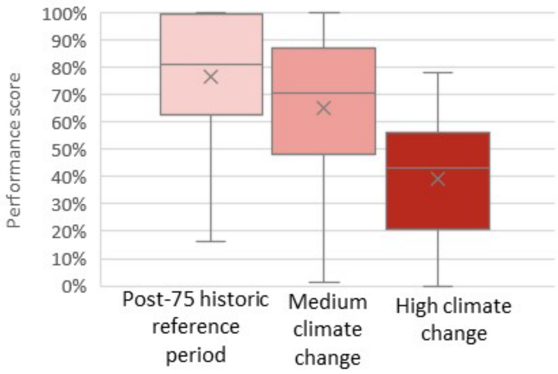


Figure 18. *Baseline performance scores of Latrobe River estuary winter - spring fresh 1 (left) and winter - spring fresh 2 (right) for post-1975 historic climate reference period conditions, 2065 medium climate change projection and 2065 high climate change projection.*

Under high climate change conditions (drier), the risk to all environmental values (except Birds) increases to Significant or High in the Tanjil River and Latrobe River Reach 4, and High for the estuary (Table 15).

Therefore, it is important to recognise that the future will look different to the past and the following section explores the sensitivity under climate change for the changes in risk associated with possible conditions on access to water.

Table 15. Risk for the baseline under a range of climate futures (presented as maximum risk for each value)

	Environmental value	Post-1975 historic climate reference period	2065 Medium Climate	2065 High Climate
Latrobe River Reach 4	Vegetation – submerged & emergent	Medium	Significant	High
	Vegetation – riparian & floodplain	Medium	Significant	High
	Fish	High	High	High
	Birds	Low	Medium	Medium
	Aquatic mammals	High	High	High
	Frogs	Medium	Significant	Significant
	Turtles	Medium	Medium	Significant
Latrobe River estuary	Vegetation – submerged & emergent	High	High	High
	Vegetation – riparian & floodplain	Significant	High	High
	Fish	High	High	High
	Birds	High	High	High
	Aquatic mammals	Significant	High	High
	Frogs	Medium	Significant	High
	Turtles	Medium	Significant	High
Tanjil River	Vegetation – submerged & emergent	Medium	Medium	Significant
	Vegetation – riparian & floodplain	Significant	Significant	Significant
	Fish	Significant	Significant	High
	Birds	Medium	Medium	Medium
	Aquatic mammals	Significant	Significant	Significant
	Frogs	Medium	Medium	Significant
	Turtles	Medium	Medium	Significant

Under a future drier climate and reduced water availability, the conditions on access to water for mine rehabilitation cannot be expected to produce the same level of change in risk to Latrobe River environmental values as has been assessed for the conditions over the post-1975 historic climate reference period.
Drier climate change projections (2065 Medium and High conditions) materially increase the risk to environmental values in the Latrobe system under all scenarios; there is similar levels of risk between the scenarios and baseline under 2065 Medium and High climate conditions. The following minor changes in risk are noted when comparing the scenarios with the Baseline, both under 2065 High Climate conditions.

- In the Tanjil River, there is a decrease in performance for summer-autumn freshes for Scenarios 3 (net historical take during winter-spring & threshold on unregulated flow harvesting), 4 (net historical take with all conditions), and 5 (gross historical take with all conditions), and an increase in performance for winter-spring freshes for Scenarios 3,4. This reflects the decreased water availability for environmental water deliveries, and an increase in the role of deliveries from Blue Rock Reservoir for mine rehabilitation (noting that this assessment is based on the current infrastructure arrangements). That is, where these deliveries are restricted to the winter-spring period (i.e. Scenario 3,4,5) then there are benefits in this season, and increased risk in the summer-autumn period.

- For Scenario 1 (full uptake, no conditions), there is reduced performance for baseflows in the Latrobe River and estuary during both the summer-autumn and winter-spring periods, reflecting some of the risks identified under the post-1975 historic climate reference period scenarios of higher levels of take.

The potential significant changes in water availability in the Latrobe system under future climate (e.g. 2065 Medium and High Climate Change predictions) are significant. It will be important for planners to consider whether the changes in risk assessed for the different scenarios (and conditions) under the post-1975 historic reference period will still be expected under a future climate.

- There were some reductions in risk to environmental values associated with conditions on the timing of take, unregulated flow limits, and an annual cap on Blue Rock Reservoir releases. These decreases in risk were reduced under a future drier climate (e.g., 2065 Medium and High climate change conditions). That is, the conditions did not produce the same level of risk reduction to environmental values as has been assessed for post-1975 historic reference period.

- There were some increases in risk to environmental values associated with higher levels of take (Scenarios 1 and 5) and this increase in risk will be maintained under Medium and High climate conditions.

The risk panel have highlighted the significance of the potential impacts to environmental values (and Traditional Owner values) under possible future drier climates (e.g. 2065 Medium and High Climate Change predictions) and recommend that adaptive management is an important tool that should be considered.

7.7 Risk to Traditional Owner values

Finding 1: The risk to Traditional Owner values under the baseline conditions is High.

Under existing conditions, the flow regime is significantly impacted by other users in the system, including power generation, urban water use, other industrial use and irrigation. This aligns with previous assessments of the water available to support environmental values, including the Latrobe Environmental Water Requirements Investigation (Alluvium 2020).

The full table of risk result for Traditional Owner values is provided below (Table 16 - Table 18). There are High or Significant risks under the Baseline scenario associated with the range of flow components across the Tanjil River, Latrobe River (Reach 4) and the Latrobe estuary.

Where these flow components are not fully provided, the following Traditional Owner values may be at risk: agriculture, aquaculture, Bunjil tambun (fishing), floodplain billabongs, gathering, historical and traditional connection, localised tourism, Native title, original/natural waterway and wetland flows, quarenook (meeting place - Lower Latrobe Wetlands), quarenook (meeting place - other sites), RAP access, river based tourism, river water quality, water based tourism (e.g. camping, tours etc), wetland based tourism, wetland water quality and woorngan (hunting).

The baseline may also pose a risk to the following core Traditional Owner values: affective, custodial, economic development (future use/returned use), identity, place-based, practice-based, relational, returned use, social cohesion, and well-being values.

Finding 2: Increasing the level of water take relative to the net historical take under the baseline, without other conditions being imposed, will materially increase the risk to Traditional Owner values.

Finding 3: Conditions on the timing of water take, unregulated flow limits, and an annual limit on Blue Rock Reservoir releases decrease risks to environmental and Traditional Owner values.

The analysis set out in Sections 7.4 and 7.5 highlights the possible changes across the scenarios to flows in the Latrobe River and estuary during the summer-autumn period. Maintaining the net historical level of take is important in not further increasing the risk to Traditional Owner values in this period (refer Scenario 1 performance results). Meanwhile, additional conditions around restricting the take to the winter-spring period, a threshold for unregulated flow harvesting and an annual cap on Blue Rock Reservoir releases are important in reducing some risks to Traditional Owner values (refer Scenario 4 performance results).

Flows in the summer-autumn period support a range of Traditional Owner values (refer Table 18). For example, these flows are important for maintaining water quality in the Lower Latrobe Wetlands. The wetlands and estuary are important to Traditional Owners as in the Creation Story, this is where Boran (pelican) crossed the

Durt'Yowan on his way south. The wetlands have also been identified as an important Quarenook (meeting place, for Bunjil Tambun (fishing), Woorngan (hunting), and gathering.

Flows through the summer-autumn period may also support water-based tourism (e.g. camping, tours etc) and economic development.

Finding 4: A future drier climate will materially increase the risk to Traditional Owner values under all scenarios. The risk to Traditional Owner values increases under 2065 Medium and High future climate conditions.

Table 16. Baseline risk assessment for Traditional Owner values: Tanjil River

Flow components	Consequence	Performance	Strength	Likelihood	Maximum risk under Baseline (post-1975 historic climate reference period)	Values supported by specific flow components	Values supported by all flow components
Summer / Autumn Baseflow	Major	High	Strong	Unlikely	Medium	River-based tourism which supports economic development (future use/returned use) values	Bunjil Tambun (fishing), gathering, Native title, original/natural waterway and wetland flows, Quarenook (meeting place - other sites), RAP access, river water quality, water-based tourism (e.g. camping, tours etc), Woorngan (hunting), historic and traditional connection; which support affective, custodial, economic development (future use/returned use), identity, place-based, practice-based, relational, returned use, social cohesion and well-being values
Summer / Autumn Fresh	Major	High	Strong	Unlikely	Medium	River-based tourism which supports economic development (future use/returned use) values and wetland water quality which supports affective, custodial, identity, place-based, practice-based, relational, returned use, social cohesion, and well-being values	
Winter / Spring Baseflow	Major	Low	Strong	Almost certain	High	River-based tourism which supports economic development (future use/returned use) values	
Winter / Spring Fresh	Major	Medium-High	Strong	Possible	Significant	River-based tourism which supports economic development (future use/returned use) values and wetland water quality which supports affective, custodial, identity, place-based, practice-based, relational, returned use, social cohesion, and well-being values	
Bankfull	Major	Medium-Low	Strong	Likely	High	River-based tourism which supports economic development (future use/returned use) values and wetland water quality which supports affective, custodial, identity, place-based, practice-based, relational, returned use, social cohesion, and well-being values	
Overbank	Major	Low	Strong	Almost certain	High	Wetland water quality which supports affective, custodial, identity, place-based, practice-based, relational, returned use, social cohesion, and well-being values; floodplain billabongs which supports affective, custodial, practice-based and well-being values; and localised tourism and wetland-based tourism which both support economic development (future use/returned use) values	
Security of entitlement	Major	Low	Strong	Almost certain	High	Agriculture and aquaculture which support economic development (future use/returned use), identity and practice-based values.	

Table 17. Baseline risk assessment for Traditional Owner values: Latrobe River

Flow components	Consequence	Performance	Strength	Likelihood	Maximum risk under Baseline (post-1975 historic climate reference period)	Values supported by specific flow components	Values supported by all flow components
Summer / Autumn Baseflow	Major	High	Strong	Unlikely	Medium	River-based tourism which supports economic development (future use/returned use) values	Bunjil Tambun (fishing), gathering, Native title, original/natural waterway and wetland flows, Quarenook (meeting place - other sites), RAP access, river water quality, water-based tourism (e.g. camping, tours etc), Woorngan (hunting), historic and traditional connection; which support affective, custodial, economic development (future use/returned use), identity, place-based, practice-based, relational, returned use, social cohesion and well-being values
Summer / Autumn Fresh 1	Major	Medium-Low	Strong	Likely	High	River-based tourism which supports economic development (future use/returned use) values and wetland water quality which supports affective, custodial, identity, place-based, practice-based, relational, returned use, social cohesion, and well-being values	
Summer / Autumn Fresh 2	Major	Medium-High	Strong	Possible	Significant		
Winter / Spring Baseflow	Major	Medium-Low	Strong	Likely	High	River-based tourism which supports economic development (future use/returned use) values	
Winter / Spring Fresh	Major	High	Strong	Unlikely	Medium	River-based tourism which supports economic development (future use/returned use) values and wetland water quality which supports affective, custodial, identity, place-based, practice-based, relational, returned use, social cohesion, and well-being values	
Bankfull	Major	Medium-High	Strong	Possible	Significant	River-based tourism which supports economic development (future use/returned use) values and wetland water quality which supports affective, custodial, identity, place-based, practice-based, relational, returned use, social cohesion, and well-being values	
Overbank	Major	High	Strong	Unlikely	Medium	Wetland water quality which supports affective, custodial, identity, place-based, practice-based, relational, returned use, social cohesion, and well-being values; floodplain billabongs which supports affective, custodial, practice-based and well-being values; and localised tourism and wetland-based tourism which both support economic development (future use/returned use) values	
Security of entitlement	Major	Low	Strong	Almost certain	High	Agriculture and aquaculture which support economic development (future use/returned use), identity and practice-based values.	

Table 18. Baseline risk assessment for Traditional Owner values: Latrobe River estuary and Lower Latrobe Wetlands

Flow components	Consequence	Performance	Strength	Likelihood	Maximum risk under Baseline (post-1975 historic climate reference period)	Values supported by specific flow components	Values supported by all flow components
Summer / Autumn Baseflow	Major	Medium-Low	Strong	Likely	High	River-based tourism which supports economic development (future use/returned use) values	Bunjil Tambun (fishing), gathering, Native title, original/natural waterway and wetland flows, Quarenook (meeting place - other sites), RAP access, river water quality, water-based tourism (e.g. camping, tours etc), Woorngan (hunting), historic and traditional connection; which support affective, custodial, economic development (future use/returned use), identity, place-based, practice-based, relational, returned use, social cohesion and well-being values
Summer / Autumn Fresh 1	Major	Low	Strong	Almost certain	High	River-based tourism which supports economic development (future use/returned use) values; wetland water quality which supports affective, custodial, identity, place-based, practice-based, relational, returned use, social cohesion, and well-being values; and wetland-based tourism which supports economic development (future use/returned use) values	
Summer / Autumn Fresh 2	Major	Medium-Low	Strong	Likely	High		
Winter / Spring Baseflow	Major	High	Strong	Unlikely	Medium	River-based tourism which supports economic development (future use/returned use) values	
Winter / Spring Fresh 1	Major	Medium-High	Strong	Possible	Significant	River-based tourism which supports economic development (future use/returned use) values; wetland water quality which supports affective, custodial, identity, place-based, practice-based, relational, returned use, social cohesion, and well-being values; and wetland-based tourism which supports economic development (future use/returned use) values	
Winter / Spring Fresh 2	Major	Medium-High	Strong	Possible	Significant		
Bankfull	Major	Medium-High	Strong	Possible	Significant	River-based tourism which supports economic development (future use/returned use) values and wetland water quality which supports affective, custodial, identity, place-based, practice-based, relational, returned use, social cohesion, and well-being values	
Overbank	Major	High	Strong	Unlikely	Medium	Wetland water quality which supports affective, custodial, identity, place-based, practice-based, relational, returned use, social cohesion, and well-being values; floodplain billabongs which supports affective, custodial, practice-based and well-being values; and localised tourism and wetland-based tourism which both support economic development (future use/returned use) values	
Security of entitlement	Major	Low	Strong	Almost certain	High	Agriculture and aquaculture which support economic development (future use/returned use), identity and practice-based values.	

8 Conclusion

This report presented the assumptions and outcomes of scenario modelling to support the LVRRS implementation action to provide guidance on potential water sources and access arrangements for mine licensees to undertake rehabilitation. It included mine rehabilitation at different levels of take, with and without seasonal constraints on take to the winter/spring period, with and without constraints on lower flow harvesting of unregulated flows, and with and without limits on annual releases from Blue Rock Reservoir by the power generators.

The following key assumptions and limitations should be considered when understanding the findings and for any further modelling or investigations that build upon the work:

- The study area is a **system in transition**, which means that the modelled representation of water resource arrangements are just a point in time and can't reflect changes to user behaviour or re-allocation of water sources. For example, the Central and Gippsland Region SWS action to re-allocate the 16 GL of the 3-4 Bench cannot be represented in the model as there is not sufficient detail of how this would be implemented. In addition, SWS Action 4-15 is developing a vision and plan for the water future of the Latrobe Valley, which may result in changes in water infrastructure arrangements.
- For the environmental and Traditional Owner values risk assessment, it is assumed that **wetland watering infrastructure improvements** are implemented to allow efficient delivery of the wetland watering requirements with the estuary flow conditions (SWS Action 8-17). This is a fundamental assumption that enables performance against the estuary flow recommendations to be used to represent any change in risk to the Lower Latrobe Wetlands (i.e. it is assumed that if the estuary flows are provided, then there is sufficient ability to provide the Lower Latrobe Wetland watering requirements).
- **Steady state vs dynamic state modelling:** All of the scenarios undertaken in this report assume steady state conditions for demand and climate. As such, this modelling approach does not model the *projected timing of mine site rehabilitation* for the different mine sites, and its overlap with *projected climate change.* Such an approach would require multi-replicate or stochastic water resource modelling that considers the likelihood of different outcomes under any given climate change and mine rehabilitation projection over time. This kind of modelling approach requires significant additional effort, and would still be subject to uncertainties with respect to climate change projections.
- **Continuous model improvements** mean that the water resource model applied in this assessment will be further developed over time with enhanced functionality and improved representations of system behaviour (e.g. through a more sophisticated representation of environmental demands) – these model improvements may change the model outputs that inform future assessments in the Latrobe River system.
- There is **uncertainty in the climate change projections** as the science and knowledge of global climate models and translation to system scale implications is constantly evolving.
- The risk assessment is built on the **best available science and knowledge** for environmental values and Traditional Owner values in the Latrobe system and their relationship with river flows. This knowledge base is continuously evolving and expanding.
- Assessment of infrastructure requirements to enable access to the water for mine rehabilitation is not within the scope of this study.

The following table provides a summary of the conditions tested on a hypothetical future with water access for mine rehabilitation and corresponding outcomes from the risk assessment and water resource assessment under post-1975 historic climate reference period conditions (Table 19). The existing risk (i.e. impact based on the modelling results) to Traditional Owner and environmental values identified in this assessment aligns with previous assessments[25] and understanding of the current system impacts on environmental and Traditional Owner values. The **current risks to environmental and Traditional Owner values under the existing baseline conditions are high**. The flows under the existing baseline conditions throughout the year do not support fish,

[25] The current risk rating to environmental and Traditional Owners values aligns with findings from previous studies undertaken for the LVRRS (Ecological Effects Study (Hale et al., 2020) and Environmental Water Requirements Investigation (Alluvium 2020)).

aquatic mammals, vegetation (wetland, riparian and floodplain) and birds in the Latrobe River, estuary and Lower Latrobe Wetlands as outlined in Environmental Water Requirements Investigation (Alluvium 2020).

The risk assessment showed that use of a maximum volume of water equivalent to the full entitlement volume held for Yallourn and Loy Yang power generation led to an increase in risk, while **maintaining water use to a maximum equivalent to net historical level of take results in no change** (i.e. no increase) in risk to environmental and Traditional Owner values. The additional conditions around restricting the take to the winter - spring period, a threshold for unregulated flow harvesting and an annual limit on Blue Rock Reservoir releases **are collectively important in reducing some risks to environmental and Traditional Owner values, noting that consistent with the baseline the overall risk rating remains High.**

The increase in risk to Traditional Owner and environmental values associated with the use of the full entitlement volume that had previously been set aside for power generation reflects the incidental benefit occurring in the baseline where underutilisation of the entitlements by power generators resulted increased spills from Blue Rock Reservoir, which supports winter-spring freshes, bankfull and overbank flows in the Tanjil River.

The risk assessment also highlighted that a lack of variability of releases at Blue Rock Reservoir (or those not aligned with appropriate ramp up and ramp down rates) may increase the risk to environmental and Traditional Owner values.

For consumptive users, under the post-1975 historic climate reference period, compared to the baseline all water access scenarios modelled led to **a decrease in reliability for rural private diverters** supplied from SRW's Latrobe River Bulk Entitlement, while there was **no impact on reliability of supply to urban water users, including industrial customers.** The most significant change was associated with use of water at a volume equivalent to the full entitlement volume, with a 12% increase in years where rural private diverters supplied from SRW's Latrobe River bulk entitlement would need to access water from the Latrobe Reserve, while other conditions resulted in 8-9% more years than in the baseline.

The loss of the incidental benefit provided by climate-resilient return flows from mine sites contributes to the decrease in reliability for rural private diverters. Even when conditions were included to limit water access for mine rehabilitation over the summer-autumn period, when irrigation demand is high, this cannot fully reduce the loss of this incidental benefit to irrigators.

In addition to the conditions on access to water for mine rehabilitation, other **complementary options to protect Traditional Owner and environmental values and irrigation reliability** could be explored. Some complementary actions have been committed to in the Central and Gippsland Region SWS, which will support irrigation users, Traditional Owner and environmental values in the Latrobe River system. Investigations have also been completed by WGCMA that may provide further opportunities on complementary options to protect environmental and Traditional Owner values.

The following measures have been committed to through the Central and Gippsland Region SWS to support environmental and Traditional Owner values and irrigation reliability in the Latrobe system:

- Reallocation of a share of water from the Latrobe 3-4 Bench bulk entitlement (SWS Action 4-8). Noting that this also aims to underpin the continued resilience and future growth of irrigated agriculture.
- New water recovery targets for the Durt'Yowan (Latrobe River) System to improve waterway health (SWS policy 8-12, 8-13, 8-14, 8-15).[26]
- Review of the Latrobe Reserve (SWS Action 4-14)
- The Victorian Government will seek to return water in the Carran Carran (Thomson River) and Durt'Yowan (Latrobe River) to the Gunaikurnai Land and Waters Aboriginal Corporation (SWS Action 6-6)
- Make available to irrigators to purchase, up to a 1% share of inflows and storage capacity of Blue Rock Reservoir (as identified in the Gippsland Region Sustainable Water Strategy, DSE 2011)
- Upgrading watering infrastructure at the Lower Latrobe Wetlands to deliver freshwater flows into the wetlands more efficiently (SWS Action 8-17)

[26] There are also targets for water recovery in the Thomson and Macalister Rivers that would contribute to the lower Latrobe estuary and wetlands (SWS Policy 8-9 and 8-10).

- Improving water management to deliver shared benefits through a combination of more flexible and efficient operations (SWS Actions 4-16, 8-16).
- Wetland watering infrastructure for the Lower Latrobe Wetlands (SWS Action 8-17). Note that for the purposes of the risk assessment, it was assumed that this infrastructure is in place (refer assumptions above).
- Reducing consumptive water use in the system such as through the introduction of alternate water supplies for consumptive use to increase the availability of surface water for the environment and to support Traditional Owner values (refer SWS Policy 4-2 and 8-16, Action 8-22 and 8-23).
- Improving fish passage in the Tyers River below Moondarra Reservoir (SWS Action 8-18).
- Managing other threats to environmental values through improved riparian vegetation management, land use management (refer SWS Action 8-25)
- Opportunities through the development of a vision and plan for the water future of the Latrobe Valley (SWS Action 4-15). The plan will determine the optimal water infrastructure arrangements to meet emerging environmental, cultural, economic and social water demands.

Projected climate change for the year 2065 could range from negligible change from current conditions (under a low climate change projection) to significantly drier conditions (under a high climate change projection). All climate projections for the year 2065 within this range are equally plausible. Under projected low climate change, conditions would be similar to those described above under post-1975 historic climate reference period. Under projected year 2065 high climate change, catchment inflows to the Latrobe River (excluding the Thomson River) would on average be 350 GL/year lower (~42% lower) than over the post-1975 historic climate reference period.

Furthermore, there would be years of negligible harvest for mine site rehabilitation (~1 GL/year in the driest year – noting that this corresponds to a repeat of the Millennium Drought under a high climate change projection [27]), and the volume and reliability of supply to all users would significantly decrease in the absence of other actions to enhance supply or reduce demand.

The risk assessment identified **significant increases in the risk** to environmental and Traditional Owner values of the Latrobe River system under a high climate change scenario at 2065. The working group acknowledged the uncertainty of a future climate and potential risks this presents to Traditional Owner and environmental values in the Latrobe River system and highlighted the **importance of ongoing adaptive management as part of the broader Latrobe Valley transition and adaptation to a changing climate** including monitoring of changes to water availability, assessment of the implications of these changes to Traditional Owners and environmental values and appropriate management (and possible policy) responses to best manage these changes.

[27] Under projected 2065 high climate change, take for mine rehabilitation can be significantly impacted if:

- At the start of the water year Blue Rock Reservoir is severely drawn down from an extended dry period such as the Millennium Drought.
- During the Winter/Spring period unregulated flows are consistently below the 447 ML/day threshold at Willow Grove.

Table 19. Summary of findings for conditions tested under the post-1975 historic climate reference period – [orange shading represents a negative change relative to the baseline, while green shading suggests positive change relative to the baseline, noting that this shading is relative to the baseline and does not represent the absolute risk rating for the scenario]

Scenario	Supply for mine rehabilitation	Impacts on consumptive users compared to the baseline scenario	Risks to Environmental and Traditional Owner values compared to the baseline scenario
Baseline consistent with average water access for power generation	No supply for mine rehabilitation. Current average annual supply for power generation: 62.8 GL/yr[28]	Rural private diverters annual reliability (based on the percentage of years over the model run in which less than 1% of the capacity of Blue Rock Reservoir is accessed from the Latrobe Reserve[29]): **98%**	The impact of the baseline (existing) conditions on environmental and Traditional Owner values in the Latrobe system is **High**[30]
		Reliability of supply to urban water users, including industrial customers: **>99%**	
Scenario 1 Water accessed for mine rehabilitation up to full entitlement volume held for power generation	Average annual supply of water for mine rehabilitation: 96.5 GL/yr	**Rural private diverters** supplied from SRW's Latrobe River bulk entitlement would need to access water from the Latrobe Reserve in **12% more years** than in the baseline	Increasing the level of take relative to the baseline, without other conditions, **materially increases the risk** to environmental values and Traditional Owner values, including through reduced critical flows during the summer-autumn period in the Latrobe River and estuary.
		Reliability of supply to urban water users, including industrial customers is unchanged.	
Scenario 2 Limit on take for mine rehabilitation equivalent to net historical water accessed for power generation – taking into account average return flows from the mine sites	Average annual supply of water for mine rehabilitation: 39.0 GL/yr	**Rural private diverters** supplied from SRW's Latrobe River bulk entitlement would need to access water from the Latrobe Reserve in **8% more years** than in the baseline	**No increased risk** relative to the baseline in the Tanjil River, Latrobe River and Latrobe estuary (and wetlands), assuming other system operations and return flows remain the same.
	Continuous supply maintained (of any volume > 1 ML/d)	Reliability of supply to urban water users, including industrial customers is unchanged.	

[28] Note that the baseline included return flows from mine sites

[29]The 2022 Central and Gippsland Region SWS recommitted to an additional 1% share of Blue Rock Reservoir being made available for irrigators. However, it is important to note that how that water is made available will be decided in consultation with stakeholders and with regard to a concurrent commitment to reallocate 16 GL from the 3-4 Bench bulk entitlement to support irrigation, environmental values and Traditional Owner self-determined outcomes. Hence, the definition of reliability of supply used here is nominal only, reflecting a system in transition.

[30] The current risk rating to environmental and Traditional Owners values aligns with findings from previous studies undertaken for the LVRRS (Ecological Effects Study (Hale et al., 2020) and Environmental Water Requirements Investigation (Alluvium 2020)).

Scenario	Supply for mine rehabilitation	Impacts on consumptive users compared to the baseline scenario	Risks to Environmental and Traditional Owner values compared to the baseline scenario
Scenario 3 As above, with conditions that restrict access to water in winter-spring, and a threshold to prevent winter-spring baseflow from being diverted	Average annual supply of water for mine rehabilitation: 38.7 GL/yr Continuous supply maintained, but only over 180 days of the year from Jun-Nov.	**Rural private diverters** supplied from SRW's Latrobe River bulk entitlement would need to access water from the Latrobe Reserve in **9% more years** than in the baseline. Reliability of supply to other users, including urban and industrial customers is unchanged.	Conditions on the timing of take with a threshold to prevent winter-spring baseflow from being diverted **materially decreases risks** to environmental and Traditional Owner values, through protecting flows in the summer-autumn period in the Latrobe River and estuary, and Winter/Spring flows in the Tanjil River.
Scenario 4 As above with limits to water access from Blue Rock Reservoir	Average annual supply of water for mine rehabilitation: 37.7 GL/yr Supply reduced to 130-150 days per year over the 180-day Jun-Nov period in the driest year modelled.	**Rural private diverters** supplied from SRW's Latrobe River bulk entitlement would need to access water from the Latrobe Reserve in **8% more years** than in the baseline. Reliability of supply to urban water users, including industrial customers is unchanged.	The combination of an annual limit on Blue Rock releases with the condition to restrict take to winter-spring and a threshold to prevent winter-spring baseflow from being diverted **materially decreases risks** to environmental and Traditional Owner values.
Scenario 5 As above, but increasing the maximum water access to the volume equivalent to the gross historic volume taken during power generation.	Average annual supply of water for mine rehabilitation: 58.1 GL/yr Supply reduced to 131-145 days per year over the 180-day Jun-Nov period in the driest year modelled.	**Rural private diverters** supplied from SRW's Latrobe River bulk entitlement would need to access water from the Latrobe Reserve in **9% more years** than in the baseline. Reliability of supply to urban water users, including industrial customers is unchanged.	Taking water at gross historical take with conditions in place **materially decreases some risks and materially increases other risks** to environmental and Traditional Owner values in the Tanjil River relative to the baseline. It does not change the risk to environmental values in the Latrobe River and estuary relative to the baseline.

9 References

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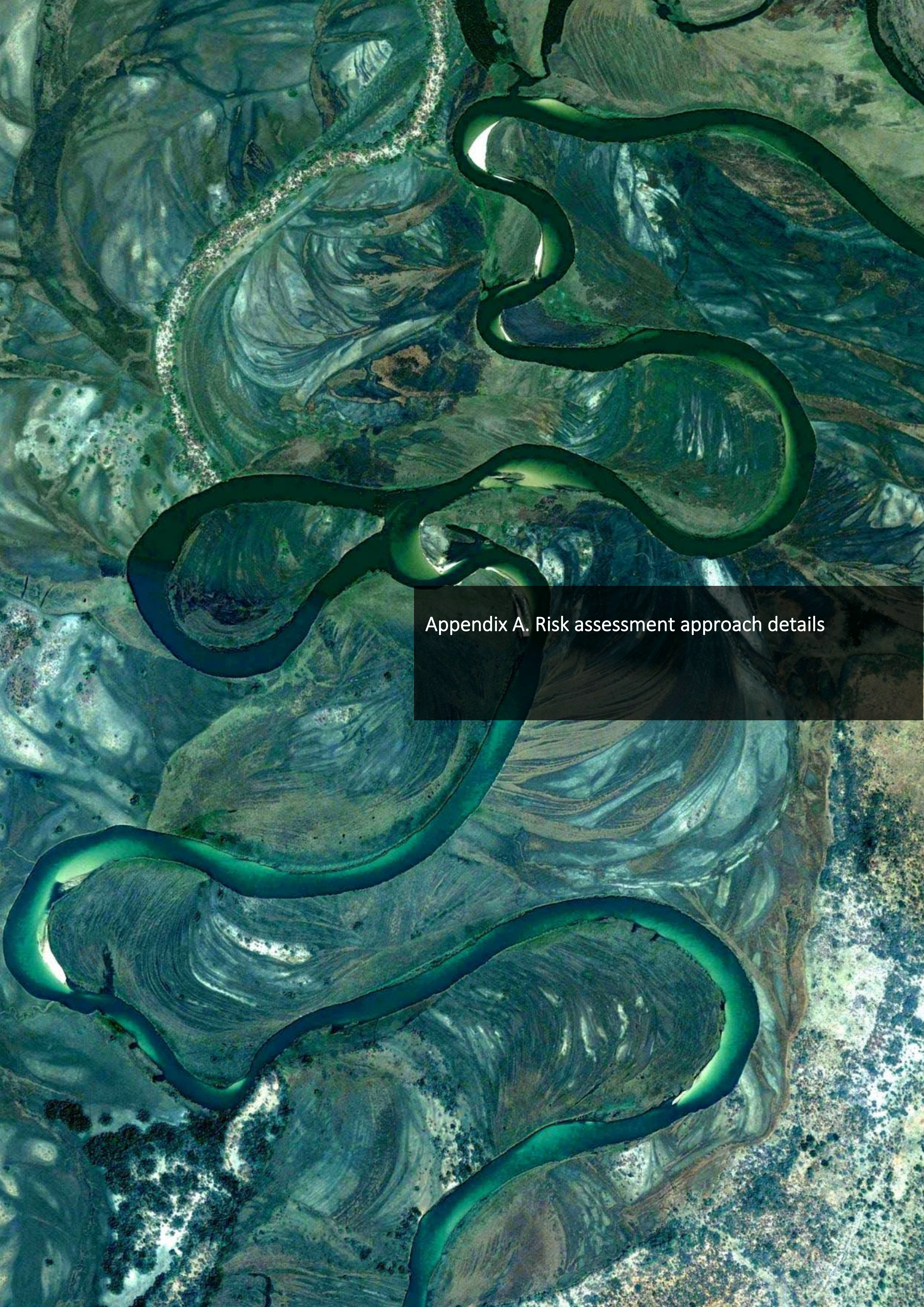


Appendix A. Risk assessment approach details

Appendix A1: Risk assessment steps

The following steps reflect the context of this project and the DEECA risk framework.

Step 1. Consequence ratings

Consequence is the effect on values if the hydrological regime of the given water management scenario does not support the values. Embedded with the consequence assessment is a ranking of the relative importance of the value or consequence of its loss informed by the value of interest and the location of that use or value of interest. The relative consequence ratings are set out in Table 1, which includes two components:

- Significance of different species and communities
- Significance of the location in relation to the broader reach, system and region.

Combing these two components means that the consequence rating gives effect to aspects of timescale and geographic scale. Loss from a reach could be recovered if loss from the Latrobe system did not occur (i.e. with some time recolonisation could occur). However such colonisation may not be possible if the subject reach provided the only known or remaining habitat for the species or community.

Table 20. Consequence matrix for environmental values (DEECA risk framework description provided next to consequence ratings)

	Habitat provided by location is critical to population in reach	Habitat provided by location is critical to population in the Latrobe system	Habitat provided by location is critical to population in the region / state
A range of species including species of local/ regional significance	**Minor** Limited effect on the natural and/or built environment and/or the environment suffers harm for 1-5 years Environmental recovery on a minor scale up to 5 years Restricted to single township or locality	**Moderate** Moderate effect on the natural and/or built environment and/or environment suffers harm for 5-10 years Environmental recovery on a small scale and/or over a period 5-10 years Impacts on a municipality	**Major** Major effect on the natural and/or built environment and/or environment suffers harm for 10-20 years Environmental recovery on a large scale and/or over a period of 10-20 years Impacts on a region or multiple municipalities
Species of state or national significance	**Moderate** Moderate effect on the natural and/or built environment and/or environment suffers harm for 5-10 years Environmental recovery on a small scale and/or over a period 5-10 years Impacts on a municipality	**Major** Major effect on the natural and/or built environment and/or environment suffers harm for 10-20 years Environmental recovery on a large scale and/or over a period of 10-20 years Impacts on a region or multiple municipalities	**Extreme** Very serious effect on the natural and/or built environment and/or environment suffers long term harm (20+ years) Environmental recovery on a very large scale and/or over a long period (20+ years) Impacts on the state or multiple regional directorates

For the purpose of this risk assessment, all Traditional Owner values have been rated as Major consequence (with different strengths assigned (under likelihood). The risk ratings applied to each environmental value and location are provided in Appendix A1.

Step 2. Likelihood ratings

Likelihood is the probability that the hydrological regime impacts the values. Likelihood has two parts:

- Performance: Likelihood that a flow component is not met by the given water management scenario. (A high level of performance would produce a lower level of risk to a value of interest)
- Strength of relationship. Likelihood that if the hydrological indicator is not met, that it will impact the value

Performance

The performance assessment evaluates how well the scenarios perform against the environmental flow recommendations.

The flow recommendations from the Latrobe Environmental Water Requirements Investigation (Alluvium 2020) are adopted here (see Appendix A3). As this study is focused on hydrological changes in the Latrobe system only, we have based the performance assessment and risk assessment on the Latrobe River contribution to the estuary flow requirements. Adjusted flow requirements for the Latrobe contribution to the estuary are provided in Appendix A5 and are based on an analysis of the contribution of the Latrobe and Thomson catchments to the estuary under unimpacted flows. This approach best demonstrates the potential change between the scenarios assessed.

Using eFlow Projector, the performance assessment considered aspects of flow magnitude, timing, frequency, duration and independence, and produced a score between 0% and 100% for each flow component, in each reach, for each water year on record:

- 0% indicates that the flow recommendation was never achieved in that water year
- 100% indicates that the environmental flow recommendations were achieved in full during that water year.

The performance scores for each scenario and further information on the performance approach are provided in Appendix A4. The performance scores were translated into one of four performance ratings for inclusion into the likelihood rating for the risk assessment (Table 21).

The absolute performance rating was used in the risk assessment for the Baseline scenario, while the relative change in performance scores relative to the Baseline scores was assessed for other scenarios.

Note that the performance assessment does not directly consider overperformance (i.e. if flows are significantly higher than the flow recommendation). Instead, the Risk Panel reviewed the hydrology to identify any issues of overperformance.

Table 21. Performance matrix

Performance rating	Criteria for performance
High performance	*> 85%*
Med-High performance	*75-85%*
Medium- Low performance	*60-75%*
Low performance	*<60%*

Strength of association / importance

Strength of association (or importance) specifies how important the flow component is to a value. The following categories are used to assign strength of association to a relationship.

Table 22. Strength/ importance categories

<table>
<tr><th>Strength / Importance rating</th><th>Definition</th><th>Implication for risk assessment</th></tr>
<tr><td>Strong</td><td>Changes in hydrological indicator will cause a significant change in the value
e.g. provision of habitat and food sources critical to survival for fish</td><td rowspan="2">Included in risk assessment based on evidence from previous studies (Latrobe Environmental Water Requirements Investigation, Environmental Effect Study)</td></tr>
<tr><td>Moderate</td><td>Changes in condition will cause moderate change in the key value or change only occurs under some circumstances
e.g. spawning opportunities important for fish, but could be missed in 1 year</td></tr>
<tr><td>Weak</td><td>Changes in condition will cause minor change in the key value or change only occurs under some circumstances</td><td>Not included in risk assessment</td></tr>
</table>

The strength / importance ratings applied to each environmental value, location and flow component are provided in Appendix A2. The strength / importance ratings for Traditional Owner values are also provided in Appendix A2.

The two assessments of performance and strength of association will be combined as follows to determine a likelihood rating. If there is high performance and a moderate importance, this will result in a 'Rare' likelihood of impact rating, while low performance and strong importance will result in a rating of 'Almost Certain' likelihood of impact rating.

Table 23. Likelihood matrix (DEECA risk framework description provided next to likelihood ratings)

<table>
<tr><th colspan="2" rowspan="2">Likelihood assessment</th><th colspan="2">Strength of association / Importance</th></tr>
<tr><th>Moderate</th><th>Strong</th></tr>
<tr><td rowspan="4">Performance</td><td>High performance</td><td>Rare
Event may occur only in exceptional circumstances</td><td>Unlikely
The event could occur at some time. There is little opportunity, reason or means to occur</td></tr>
<tr><td>Medium-High performance</td><td>Unlikely
The event could occur at some time. There is little opportunity, reason or means to occur</td><td>Possible
The event might occur. There is some opportunity, reason or means to occur</td></tr>
<tr><td>Medium-Low performance</td><td>Possible
The event might occur. There is some opportunity, reason or means to occur</td><td>Likely
The event is likely to occur in most circumstances. There is considerable opportunity, reason or means for the event to occur</td></tr>
<tr><td>Low performance</td><td>Likely
The event is likely to occur in most circumstances. There is considerable opportunity, reason or means for the event to occur</td><td>Almost Certain
The event is expected to occur in most circumstances. There is a great opportunity, reason or means to occur</td></tr>
</table>

Step 3. Risk ratings

A risk matrix has been developed and adopted to determine risk based on the likelihood and consequence ratings. The adopted risk matrix is aligned with the DEECA Risk Management Framework.

Table 24. Risk matrix

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

Appendix A2: Location selection
Table 25. Locations to be included in risk assessment

Location Group	Location	Comments
Freshwater reaches	Latrobe River- Scarnes Bridge to Kilmany South (Reach 4)	Priority reach for Latrobe freshwater reach Reach 4 is downstream of tributaries so selected in preference to Reach 3 (Lake Narracan to Scarnes Bridge).
	Tanjil River (Reach 8)	Included given it will have the greatest degree of hydrological change but noting that there are other threats to environmental values in this reach that may limit benefits.
Latrobe estuary	Latrobe estuary (Reach 6) and Lower Latrobe Wetlands	Representative of potential impacts on estuary and Lower Latrobe Wetlands. As this study is focused on hydrological changes in the Latrobe system only, we have based the assessment location on the Latrobe River upstream of the confluence with the Thomson River[31] It is assumed that upgrades to wetland infrastructure included in the SWS are implemented to ensure that if estuary flows are met, then wetland watering requirements can be achieved.
Not included in risk assessment	Latrobe River - Lake Narracan to Scarnes Bridge (Reach 3)	Hydrological site for this reach is downstream of Morwell River but upstream of Tyers River and Traralgon Creek, so mixed response to changes. There is only a short reach before Tyres River confluence. Therefore Reach 4 provides a better representation of the majority of the Latrobe River downstream of Lake Narracan and a better representation of potential changes in hydrology.
	Latrobe River – Kilmany South to Thomson River Confluence (Reach 5)	Not included as part of estuary and also typically high performance with flow recommendations so difficult to assess risk. Any changes in flow regime would be captured by Reach 4 (immediately upstream) or Latrobe contribution to estuary (downstream end of Reach 5).
	Tyers River (Reach 9)	High priority waterway for WGCMA. No differences between scenarios expected for his reach. Could be included in future assessments if other changes to system operation or water use are being explored.
	Morwell River (Reach 10) Traralgon Creek (Reach 11)	Return flows from power generation may impact on waterway values, but not significant compared to extent of the reach and has been explored previously (Environmental Effects Study and Latrobe Environmental Water Requirements Investigation). No changes between different conditions being tested in the project so not the focus of the risk assessment.

[31] As this study is focused on hydrological changes in the Latrobe system only, we have based the performance assessment and risk assessment on the Latrobe River contribution to the estuary flow requirements. Adjusted flow requirements for the Latrobe contribution to the estuary are provided in Appendix A5 and are based on an analysis of the contribution of the Latrobe and Thomson catchments to the estuary under unimpacted flows. This approach best demonstrates the potential change between the scenarios assessed.

Appendix A3: Consequence rating table and rationale

Table 26. Consequence rating and its rationale for each environmental value at Latrobe River reach 4, Tanjil River reach 8 and the Latrobe Estuary

Location	Value	Species	How important is location to overall population in Latrobe	Overall consequence rating	Rationale
Reach 4	Aquatic mammals	State / National significance	Critical	Major	Platypus is now listed as 'Vulnerable' in Victoria based on IUCN criteria. They are regarded as significant by local communities and will only persist if the correct habitat and food resource conditions exist
Reach 8	Aquatic mammals	State / National significance	Only critical to reach	Moderate	Platypus is now listed as 'Vulnerable' in Victoria based on IUCN criteria. They are regarded as significant by local communities and will only persist if the correct habitat and food resource conditions exist. Lower condition waterway
Estuary	Birds	State / National significance	Critical	Major	Lower Latrobe Wetlands Ramsar listing; Community of many important birds
Reach 4	Birds	Local / Regional significance	Only critical to reach	Minor	One species of national significance, but as a community not that important
Reach 8	Birds	Local / Regional significance	Only critical to reach	Minor	One species of national significance, but as a community not that important. Poor condition
Estuary	Fish	State / National significance	Critical	Major	Species of National Significance. 31 native species observed in this reach out of 35 in the Latrobe system (inc. wetlands).
Reach 4	Fish	State / National significance	Critical	Major	Species of National Significance. 16 native species observed in this reach out of 35 in the Latrobe system (inc. wetlands).
Reach 8	Fish	State / National significance	Only critical to reach	Moderate	Species of National Significance. 16 native species observed in this reach out of 35 in the Latrobe system (inc. wetlands).
Estuary	Frogs	State / National significance	Only critical to reach	Moderate	Part of Ramsar site, listed in limits of acceptable change. Also EPBC listed species at this site.
Reach 4	Frogs	Local / Regional significance	Only critical to reach	Minor	At least 13 species of frog are present within the Latrobe system, but are mostly found around the freshwater swamps in the Lower Latrobe system.
Reach 8	Frogs	Local / Regional significance	Only critical to reach	Minor	At least 13 species of frog are present within the Latrobe system, but are mostly found around the freshwater swamps in the Lower Latrobe system.
Estuary	Turtles	Local / Regional significance	Critical	Moderate	Only one turtle species observed at this reach: Data deficient in Victorian Advisory List

Location	Value	Species	How important is location to overall population in Latrobe	Overall consequence rating	Rationale
Reach 4	Turtles	Local / Regional significance	Critical	Moderate	Only one turtle species observed at this reach: Data deficient in Victorian Advisory List
Reach 8	Turtles	Local / Regional significance	Only critical to reach	Minor	None listed
Estuary	Vegetation - Submerged/ Emergent	State / National significance	Critical	Major	Ramsar site - Lower Latrobe Wetlands. Several vegetation species listed in Victorian Advisory List and one EPBC listed species
Estuary	Vegetation - Riparian / Floodplain	State / National significance	Critical	Major	Ramsar site - Lower Latrobe Wetlands. Several vegetation species listed in Victorian Advisory List and one EPBC listed species
Reach 4	Vegetation - Submerged/ Emergent	Local / Regional significance	Critical	Moderate	Three Endangered EVCs. Regional Significance
Reach 4	Vegetation - Riparian / Floodplain	Local / Regional significance	Critical	Moderate	Three Endangered EVCs. Regional Significance
Reach 8	Vegetation - Submerged/ Emergent	Local / Regional significance	Only critical to reach	Minor	Four Vulnerable EVCs and one Endangered EVC. Regional significance but poor condition reach.
Reach 8	Vegetation - Riparian / Floodplain	Local / Regional significance	Only critical to reach	Minor	Four Vulnerable EVCs and one Endangered EVC. Regional significance but poor condition reach.

Appendix A4: Strength / importance ratings

The following two tables provide the linkages between flow components and values, and where these linkages occur, for environmental and Traditional Owner values. There are many interdependencies and supporting values that are also noted in these tables.

Table 27. Strength /importance ratings for how flow components support environmental values

Value	Location	Flow component	Strength / importance rating	Rationale for strength / importance rating	Description of linkage	Secondary benefits to wetlands	Supporting values		
							Macroinvertebrates	Water quality	Geomorphology
Aquatic mammals	Reach 4	Summer / Autumn Baseflow	Strong	Critical for maintaining existing populations	Provide pool habitat for refuge/permanent habitat				
Aquatic mammals	Reach 4	Summer / Autumn Fresh 2	Strong	Important for improving extent. Connectivity for local movement	Provide longitudinal connectivity between reaches for local movement Supporting values - macroinvertebrates support Frogs population: Sustain macroinvertebrate and zooplankton communities during summer as a food source for fish, frog and platypus (Balagen) populations Requires WQ as a supporting value: Flush pools to maintain good dissolved oxygen levels, low salinity and low nutrients in the water column to support aquatic ecosystems (e.g. fish, macroinvertebrate populations and zooplankton)				
Aquatic mammals	Reach 4	Winter / Spring Fresh	Moderate	Important for improving extent. Flushing sediments to maintain macroinvertebrate as food source	Flow freshes to keep fine sediment from infilling gravel beds and allow large macroinvertebrate populations for food Geomorphology as a supporting value: Provide flows that establish and maintain high flow benches (scour and deposit sediment on high flow benches) Macroinvertebrate as a supporting value: Create and extend aquatic habitats for macroinvertebrates and zooplankton				
Aquatic mammals	Reach 4	Winter / Spring Baseflow	Moderate	Important for improving extent. Flushing sediments to maintain macroinvertebrate as food source	Flow freshes to keep fine sediment from infilling gravel beds and allow large macroinvertebrate populations for food				
Aquatic mammals	Reach 4	Bankfull risk	Moderate	Risk to be managed (breeding opportunities; allowing for foraging)	Support breeding opportunities by avoiding bankfull flows Avoid extended high flows events to allow for foraging				
Aquatic mammals	Reach 8	Summer / Autumn Baseflow	Strong	Critical for maintaining existing populations	Provide pool habitat for refuge/permanent habitat				
Aquatic mammals	Reach 8	Summer / Autumn Fresh	Strong	Important for improving extent. Connectivity for local movement	Provide longitudinal connectivity between reaches for local movement Supporting values - macroinvertebrates support Frogs population: Sustain macroinvertebrate and zooplankton communities during summer as a food source for fish, frog and platypus (Balagen) populations Requires WQ as a supporting value: Flush pools to maintain good dissolved oxygen levels, low salinity and low nutrients in the water column to support aquatic ecosystems (e.g. fish, macroinvertebrate populations and zooplankton)				
Aquatic mammals	Reach 8	Winter / Spring Fresh	Moderate	Important for improving extent. Flushing sediments to maintain macroinvertebrate as food source	Flow freshes to keep fine sediment from infilling gravel beds and allow large macroinvertebrate populations for food Geomorphology as a supporting value: Provide flows that establish and maintain high flow benches (scour and deposit sediment on high flow benches) Macroinvertebrate as a supporting value: Create and extend aquatic habitats for macroinvertebrates and zooplankton				
Aquatic mammals	Reach 8	Winter / Spring Baseflow	Moderate	Important for improving extent. Flushing sediments to maintain macroinvertebrate as food source	Flow freshes to keep fine sediment from infilling gravel beds and allow large macroinvertebrate populations for food				
Aquatic mammals	Reach 8	Bankfull risk	Moderate	Risk to be managed (breeding opportunities; allowing for foraging)	Support breeding opportunities by avoiding bankfull flows Avoid extended high flows events to allow for foraging				
Birds	Reach 4	Overbank	Moderate	Important for wetlands, floodplain areas	Flooding of riparian vegetation for foraging habitat				
Birds	Reach 8	Overbank	Moderate	Important for wetlands, floodplain areas	Flooding of riparian vegetation for foraging habitat				
Birds	Estuary - Latrobe only	Overbank	Strong	Important for wetlands, floodplain areas	Wetland watering (fill) to stimulate bird breeding, nesting, foraging activities and food supply Wetland watering (fill) for inundating fringing vegetation to encourage water birds to forage Inundation of floodplain and riparian vegetation provides habitat for riparian zone birds				

Value	Location	Flow component	Strength / importance rating	Rationale for strength / importance rating	Description of linkage	Secondary benefits to wetlands	Supporting values		
							Macroinvertebrates	Water quality	Geomorphology
Birds	Estuary - Latrobe only	Summer / Autumn Fresh 1	Moderate	Not critical (access to fresh drinking water in estuary)	Provide freshwater conditions for birds			✓	
Birds	Estuary - Latrobe only	Winter / Spring Fresh 1	Strong	Important for wetland watering	Wetland watering (partial fill and fill) to stimulate bird breeding, nesting, foraging activities and food supply Wetland watering (fill) for inundating fringing vegetation to encourage water birds to forage	✓		✓	
Fish	Reach 4	Summer / Autumn Baseflow	Strong	Maintaining pools for habitat, food	Maintain permanent deep pool, minimum depth 2 m, for habitat and food sources Requires WQ as a supporting value: Maintain dissolved oxygen levels in pools above thresholds for gill-breathing organisms (fish, macroinvertebrates and zooplankton) during summer/autumn			✓	
Fish	Reach 4	Summer / Autumn Fresh 2	Strong	Fresh for movement, migration	For spawning (freshwater migratory fish). Provide water over riffles to allow longitudinal connectivity, for fish to move between pools to feed, grow and find new habitats (allow juvenile Tupong to move upstream), for juveniles to migrate upstream from estuary and sea Longitudinal connection in channel for adult grayling movement Migration of grayling larvae, small-bodied migratory fish, Australian Bass adults from freshwater to estuary and downstream juvenile habitat Downstream migration of eels (noy yang) to allow for ocean breeding Submerge and clean woody debris and hard surfaces to provide breeding substrate Supporting values - macroinvertebrates support Frogs population: Sustain macroinvertebrate and zooplankton communities during summer as a food source for fish, frog and platypus (Balagen) populations Requires WQ as a supporting value: Flush pools to maintain good dissolved oxygen levels, low salinity and low nutrients in the water column to support aquatic ecosystems (e.g. fish, macroinvertebrate populations and zooplankton)		✓	✓	
Fish	Reach 4	Winter / Spring Fresh	Strong	Fresh for movement, migration	Provide water over riffles to allow longitudinal connectivity and for fish to move between pools to feed, grow and find new habitats (allow juvenile Tupong to move upstream. Allow upstream movement of juvenile Australian Bass into freshwater habitats Juveniles of graylings migrate upstream from sea Migration of grayling larvae from freshwater to estuary and downstream juvenile habitat Provide prolonged seasonal inundation of vegetation beds and instream benches as habitat to stimulate invertebrate hatching and fish breeding Submerge and clean woody debris and hard surfaces to provide breeding substrate				
Fish	Reach 8	Summer / Autumn Baseflow	Strong	Maintaining pools for habitat, food	Provide water in pools for habitat and food sources Requires WQ as a supporting value: Maintain dissolved oxygen levels in pools above thresholds for gill-breathing organisms (fish, macroinvertebrates and zooplankton) during summer/autumn			✓	
Fish	Reach 8	Summer / Autumn Fresh	Strong	Fresh for movement, migration	Provide water over riffles to allow longitudinal connectivity, for fish to move between pools to feed, grow and find new habitats (allow juvenile Tupong to move upstream). Provide connectivity to allow small-bodied migratory fish to migrate downstream to breed Submerge and clean woody debris and hard surfaces to provide breeding substrate Supporting values - macroinvertebrates support Frogs population: Sustain macroinvertebrate and zooplankton communities during summer as a food source for fish, frog and platypus (Balagen) populations Requires WQ as a supporting value: Flush pools to maintain good dissolved oxygen levels, low salinity and low nutrients in the water column to support aquatic ecosystems (e.g. fish, macroinvertebrate populations and zooplankton)		✓	✓	
Fish	Reach 8	Winter / Spring Fresh	Strong	Fresh for movement, migration	Provide water over riffles to allow longitudinal connectivity and for fish to move between pools to feed, grow and find new habitats (allow juvenile Tupong to move upstream. Allow upstream movement of juvenile Australian Bass into freshwater habitats Juveniles of graylings migrate upstream from sea Migration of grayling larvae from freshwater to estuary and downstream juvenile habitat Provide prolonged seasonal inundation of vegetation beds and instream benches as habitat to stimulate invertebrate hatching and fish breeding Submerge and clean woody debris and hard surfaces to provide breeding substrate				
Fish	Estuary - Latrobe only	Summer / Autumn Baseflow	Moderate	Freshwater in estuary	Provide freshwater conditions above halocline for fish			✓	
Fish	Estuary - Latrobe only	Summer / Autumn Fresh 1	Moderate	Freshwater in estuary	Provide freshwater conditions above halocline for fish Wetland watering (partial fill) to encourage fish reproduction			✓	
Fish	Estuary - Latrobe only	Winter / Spring Baseflow	Moderate	Maintaining pools through flushing sediment	Provide freshwater conditions above halocline for fish			✓	

Value	Location	Flow component	Strength / importance rating	Rationale for strength / importance rating	Description of linkage	Secondary benefits to wetlands	Supporting values		
							Macroinvertebrates	Water quality	Geomorphology
Fish	Estuary - Latrobe only	Winter / Spring Fresh 1	Moderate	Freshwater in estuary	Provide freshwater conditions above halocline for fish Wetland watering (partial fill) to encourage fish reproduction Wetland watering (partial fill and fill) to encourage spawning for Black Beam				
Fish	Estuary - Latrobe only	Winter / Spring Fresh 2	Strong	Fully flushing estuary for Grayling movement	Provide salinity gradient for Grayling				
Fish	Estuary - Latrobe only	Overbank	Moderate	Wetland flushing. Not very important for fish	Wetland watering (flushing flows) to support fish migration into ad between wetlands and into river				
Frogs	Reach 4	Summer / Autumn Fresh 1	Strong	maintain water quality in habitat	Provide pool habitat Requires WQ as a supporting value: Flush pools to maintain good dissolved oxygen levels, low salinity and low nutrients in the water column to support aquatic ecosystems (e.g. fish, macroinvertebrate populations and zooplankton)				
Frogs	Reach 4	Summer / Autumn Fresh 2	Moderate	Maintain habitat	Supporting values - macroinvertebrates support Frogs: Sustain macroinvertebrate and zooplankton communities during summer as a food source for fish, frog and platypus (Balagen) populations				
Frogs	Reach 4	Winter / Spring Fresh	Strong	Support macroinvertebrates as food source	Allow growth and reproduction of macroinvertebrate communities Provide longitudinal connectivity between reaches				
Frogs	Reach 8	Summer / Autumn Fresh	Strong	maintain water quality in habitat	Provide pool habitat Supporting values - macroinvertebrates support Frogs population: Sustain macroinvertebrate and zooplankton communities during summer as a food source for fish, frog and platypus (Balagen) populations Requires WQ as a supporting value: Flush pools to maintain good dissolved oxygen levels, low salinity and low nutrients in the water column to support aquatic ecosystems (e.g. fish, macroinvertebrate populations and zooplankton)				
Frogs	Reach 8	Winter / Spring Fresh	Strong	Support macroinvertebrates as food source	Allow growth and reproduction of macroinvertebrate communities Provide longitudinal connectivity between reaches				
Frogs	Estuary - Latrobe only	Winter / Spring Fresh 1	Strong	Important for wetland watering	Wetland watering (partial fill) to provide littoral habitat Wetland watering (fill) to allow growth and reproduction of macroinvertebrate communities as food source Wetland watering (fill) for provide connectivity between river and wetlands and between wetlands				
Frogs	Estuary - Latrobe only	Bankfull	Strong	Important for wetland watering	Wetland watering (fill) to provide connectivity and movement				
Turtles	Reach 4	Summer / Autumn Baseflow	Strong	Pool habitat	Provide pool habitat.				
Turtles	Reach 4	Winter / Spring Fresh	Strong	Support macroinvertebrates as food source	Allow growth and reproduction of macroinvertebrate communities as food source				
Turtles	Reach 4	Bankfull	Moderate	Flooding riparian zones for nesting	Flooding of banks and riparian zone to create conditions for nesting				
Turtles	Reach 8	Summer / Autumn Baseflow	Strong	Pool habitat	Provide pool habitat.				
Turtles	Reach 8	Winter / Spring Fresh	Strong	Support macroinvertebrates as food source	Allow growth and reproduction of macroinvertebrate communities as food source				
Turtles	Reach 8	Bankfull	Moderate	Flooding riparian zones for nesting	Flooding of banks and riparian zone to create conditions for nesting				
Turtles	Estuary - Latrobe only	Winter / Spring Fresh 1	Strong	Wetland watering	Wetland watering (partial fill) to provide littoral habitat Wetland watering (fill) to allow growth and reproduction of macroinvertebrate communities as food source Wetland watering (fill) for flooding of banks and riparian zone to create conditions for nesting				
Turtles	Estuary - Latrobe only	Bankfull	Strong	Wetland watering	Wetland watering (fill) for flooding of banks and riparian zone to create conditions for nesting				
Vegetation - Submerged/ Emergent	Reach 4	Summer / Autumn Baseflow	Moderate	Limit terrestrial encroachment	Maintain adequate depth of permanent water in channel to limit terrestrial encroachment into aquatic habitat				

Value	Location	Flow component	Strength / importance rating	Rationale for strength / importance rating	Description of linkage	Secondary benefits to wetlands	Supporting values Macroinvertebrates	Water quality	Geomorphology
Vegetation - Submerged/ Emergent	Reach 4	Summer / Autumn Fresh 2	Strong	Support growth of emergent macrophytes	Support growth on terraces, channel edge and lower bank. Geomorphology as a supporting value: Provide flows that maintain low flow benches through Summer / Autumn (scour and deposit sediment on low flow benches)				Y
Vegetation - Submerged/ Emergent	Reach 4	Winter / Spring Fresh	Strong	mosaic of wetted areas; Inundate benches	Provide a mosaic of spatially and temporally differentially wetted areas within stream channel, benches, lower banks and wetland margins.				
Vegetation - Riparian / Floodplain	Reach 4	Winter / Spring Fresh	Strong	mosaic of wetted areas; Inundate benches	Support growth of riparian vegetation on terraces, channel edge and lower bank. Provide disturbance in riparian zone and channel to open recruitment niches for riparian plants. Especially Eucalypt species.				
Vegetation - Submerged/ Emergent	Reach 4	Bankfull	Moderate	Disturbance	Provide disturbance in riparian zone and channel to open recruitment niches for emergent plants.				
Vegetation - Riparian / Floodplain	Reach 4	Bankfull	Strong	Inundate riparian veg.	Inundate all channel vegetation and support its growth.				
Vegetation - Riparian / Floodplain	Reach 4	Overbank	Strong	Important for riparian / floodplain veg	Fill floodplain depressions and billabongs to support the growth of seasonal and emergent wetland vegetation. Inundate floodplain and provide moisture to floodplain species and promote carbon exchange. Provide mechanism for dispersal of riparian and floodplain seeds.				
Vegetation - Submerged/ Emergent	Reach 8	Summer / Autumn Baseflow	Moderate	Limit terrestrial encroachment	Maintain adequate depth of permanent water in channel to limit terrestrial encroachment into aquatic habitat				
Vegetation - Submerged/ Emergent	Reach 8	Summer / Autumn Fresh	Strong	Support growth of emergent macrophytes	Support growth on terraces, channel edge and lower bank. Geomorphology as a supporting value: Provide flows that maintain low flow benches through Summer / Autumn (scour and deposit sediment on low flow benches)				
Vegetation - Submerged/ Emergent	Reach 8	Winter / Spring Fresh	Strong	mosaic of wetted areas; Inundate benches	Provide a mosaic of spatially and temporally differentially wetted areas within stream channel, benches, lower banks and wetland margins.				
Vegetation - Riparian / Floodplain	Reach 8	Winter / Spring Fresh	Strong	mosaic of wetted areas; Inundate benches	Support growth of riparian vegetation on terraces, channel edge and lower bank. Provide disturbance in riparian zone and channel to open recruitment niches for riparian plants. Especially Eucalypt species.				
Vegetation - Submerged/Emergent	Reach 8	Bankfull	Moderate	Disturbance	Provide disturbance in riparian zone and channel to open recruitment niches for emergent plants.				
Vegetation - Riparian / Floodplain	Reach 8	Bankfull	Strong	Inundate riparian veg.	Inundate all channel vegetation and support its growth.				
Vegetation - Riparian / Floodplain	Reach 8	Overbank	Strong	Important for riparian / floodplain veg	Fill floodplain depressions and billabongs to support the growth of seasonal and emergent wetland vegetation. Inundate floodplain and provide moisture to floodplain species and promote carbon exchange. Provide mechanism for dispersal of riparian and floodplain seeds.				
Vegetation - Submerged/ Emergent	Estuary - Latrobe only	Summer / Autumn Baseflow	Moderate	Support growth of emergent macrophytes	To keep salinity low enough at mid estuary to support emergent macrophyte vegetation				
Vegetation - Submerged/ Emergent	Estuary - Latrobe only	Summer / Autumn Fresh 1	Strong	Support growth of emergent macrophytes	Wetland watering (fill) to discourage undesirable or invasive plant species (prolong inundation) Wetland watering (partial fill) to promote growth and flowering for submerged and emergent vegetation				

Value	Location	Flow component	Strength / importance rating	Rationale for strength / importance rating	Description of linkage	Secondary benefits to wetlands	Supporting values Macroinvertebrates	Water quality	Geomorphology
Vegetation - Submerged/ Emergent	Estuary - Latrobe only	Summer / Autumn Fresh 2	Moderate	Wetland watering. Mosaic of wetted areas in estuary	Wetland watering (partial fill) to promote growth and flowering for submerged and emergent vegetation				
Vegetation - Submerged/ Emergent	Estuary - Latrobe only	Winter / Spring Fresh 1	Strong	Wetland watering. Mosaic of wetted areas in estuary	Wetland watering (partial fill) to promote growth and flowering for submerged and emergent vegetation Mosaic of wetted areas for emergent vegetation.				
Vegetation - Riparian / Floodplain	Estuary - Latrobe only	Winter / Spring Fresh 1	Strong	Wetland watering. Mosaic of wetted areas in estuary	Mosaic of wetted areas for riparian vegetation. Wetland watering (fill) to encourage inundation for fringing wetland vegetation				
Vegetation - Submerged/ Emergent	Estuary - Latrobe only	Winter / Spring Fresh 2	Strong	Important for phragmites at river mouth	Support growth of Phragmites in lower Estuary during Spring				
Vegetation - Submerged/ Emergent	Estuary - Latrobe only	Winter / Spring Baseflow	Moderate	Support growth of emergent macrophytes	To keep salinity low enough at mid estuary to support emergent macrophyte vegetation				
Vegetation - Submerged/ Emergent	Estuary - Latrobe only	Bankfull	Strong	Disturbance	Displace salt wedge into Lake Wellington to limit surface water salinity to enable growth and reproduction (seed and propagule dispersal) of emergent vegetation, submerged aquatic macrophyte and fringing vegetation Disturbance to support emergent vegetation				
Vegetation - Riparian / Floodplain	Estuary - Latrobe only	Bankfull	Strong	Inundate riparian veg. Disturbance	Inundation of riparian vegetation Displace salt wedge into Lake Wellington to limit surface water salinity to enable growth and reproduction (seed and propagule dispersal) of emergent vegetation, submerged aquatic macrophyte and fringing vegetation				
Vegetation - Riparian / Floodplain	Estuary - Latrobe only	Overbank	Strong	Important for floodplain veg / wetlands	Inundation and seed dispersal for floodplain and riparian vegetation Flushing flows for wetlands - inundation of fringing wetland vegetation				
Fish	Reach 4	Summer / Autumn Fresh 1	Strong	maintain water quality in habitat	Provide pool habitat Requires WQ as a supporting value: Flush pools to maintain good dissolved oxygen levels, low salinity and low nutrients in the water column to support aquatic ecosystems (e.g. fish, macroinvertebrate populations and zooplankton)				
Fish	Reach 8	Winter / Spring Baseflow	Moderate	Important for improving extent. Flushing sediments to maintain macroinvertebrates as food source	Flow freshes to keep fine sediment from infilling gravel beds and allow large macroinvertebrate populations for food				
Fish	Reach 4	Winter / Spring Baseflow	Moderate	Important for improving extent. Flushing sediments to maintain macroinvertebrates as food source	Flow freshes to keep fine sediment from infilling gravel beds and allow large macroinvertebrate populations for food				
Aquatic mammals	Reach 4	Summer / Autumn Fresh 1	Strong	maintain water quality in habitat	Provide pool habitat Requires WQ as a supporting value: Flush pools to maintain good dissolved oxygen levels, low salinity and low nutrients in the water column to support aquatic ecosystems (e.g. fish, macroinvertebrate populations and zooplankton)				

Table 28. Strength /importance ratings for how flow components support Traditional Owner values

What	Value	Where	When	Reliance on water	Flow components	interdependencies	Comments
Original/natural waterway and wetland flows	Practice-based	All Latrobe River system waterways and associated wetlands	All year	Strong	All		
Original/natural waterway and wetland flows	Well-being	All Latrobe River system waterways and associated wetlands	All year	Strong	All		
Original/natural waterway and wetland flows	Custodial	All Latrobe River system waterways and associated wetlands	All year	Strong	All		
Original/natural waterway and wetland flows	Affective	All Latrobe River system waterways and associated wetlands	All year	Strong	All		
Original/natural waterway and wetland flows	Returned use	All Latrobe River system waterways and associated wetlands	All year	Strong	All		
Original/natural waterway and wetland flows	Place-based	All Latrobe River system waterways and associated wetlands	All year	Strong	All		
Floodplain billabongs	Practice-based	Floodplain	All year	Strong	Overbank		
Floodplain billabongs	Well-being	Floodplain	All year	Strong	Overbank		
Floodplain billabongs	Custodial	Floodplain	All year	Strong	Overbank		
Floodplain billabongs	Affective	Floodplain	All year	Strong	Overbank		
River water quality	Affective	All Latrobe River system waterways and associated wetlands	All year	Moderate	All		
River water quality	Custodial	All Latrobe River system waterways and associated wetlands	All year	Moderate	All		
River water quality	Returned use	All Latrobe River system waterways and associated wetlands	All year	Moderate	All		
River water quality	Identity	All Latrobe River system waterways and associated wetlands	All year	Moderate	All		
River water quality	Place-based	All Latrobe River system waterways and associated wetlands	All year	Moderate	All		
River water quality	Practice-based	All Latrobe River system waterways and associated wetlands	All year	Moderate	All		
River water quality	Relational	All Latrobe River system waterways and associated wetlands	All year	Moderate	All		
River water quality	Social Cohesion	All Latrobe River system waterways and associated wetlands	All year	Moderate	All		

What	Value	Where	When	Reliance on water	Flow components	interdependencies	Comments
River water quality	Well-being	All Latrobe River system waterways and associated wetlands	All year	Moderate	All		
Wetland water quality	Affective	Lower Latrobe Wetlands	All year	Strong	freshes, bankfull and overbank	Original/natural waterway and wetland flows, water quality	water reliance is moderate to differentiate from wetland water quality. Wetland water quality is more attuned to water regime whereas river water quality is also affected by land use, erosion etc at a larger scale
Wetland water quality	Custodial	Lower Latrobe Wetlands	All year	Strong	freshes, bankfull and overbank	Original/natural waterway and wetland flows, water quality	water reliance is moderate to differentiate from wetland water quality. Wetland water quality is more attuned to water regime whereas river water quality is also affected by land use, erosion etc at a larger scale
Wetland water quality	Returned use	Lower Latrobe Wetlands	All year	Strong	freshes, bankfull and overbank	Original/natural waterway and wetland flows, water quality	water reliance is moderate to differentiate from wetland water quality. Wetland water quality is more attuned to water regime whereas river water quality is also affected by land use, erosion etc at a larger scale
Wetland water quality	Identity	Lower Latrobe Wetlands	All year	Strong	freshes, bankfull and overbank	Original/natural waterway and wetland flows, water quality	water reliance is moderate to differentiate from wetland water quality. Wetland water quality is more attuned to water regime whereas river water quality is also affected by land use, erosion etc at a larger scale
Wetland water quality	Place-based	Lower Latrobe Wetlands	All year	Strong	freshes, bankfull and overbank	Original/natural waterway and wetland flows, water quality	water reliance is moderate to differentiate from wetland water quality. Wetland water quality is more attuned to water regime whereas river water quality is also affected by land use, erosion etc at a larger scale
Wetland water quality	Practice-based	Lower Latrobe Wetlands	All year	Strong	freshes, bankfull and overbank	Original/natural waterway and wetland flows, water quality	water reliance is moderate to differentiate from wetland water quality. Wetland water quality is more attuned to water regime whereas river water quality is also affected by land use, erosion etc at a larger scale
Wetland water quality	Relational	Lower Latrobe Wetlands	All year	Strong	freshes, bankfull and overbank	Original/natural waterway and wetland flows, water quality	water reliance is moderate to differentiate from wetland water quality. Wetland water quality is more attuned to water regime whereas river water quality is also affected by land use, erosion etc at a larger scale
Wetland water quality	Social Cohesion	Lower Latrobe Wetlands	All year	Strong	freshes, bankfull and overbank	Original/natural waterway and wetland flows, water quality	water reliance is moderate to differentiate from wetland water quality. Wetland water quality is more attuned to water regime whereas river water quality is also affected by land use, erosion etc at a larger scale
Wetland water quality	Well-being	Lower Latrobe Wetlands	All year	Strong	freshes, bankfull and overbank	Original/natural waterway and wetland flows, water quality	water reliance is moderate to differentiate from wetland water quality. Wetland water quality is more attuned to water regime whereas river water quality is also affected by land use, erosion etc at a larger scale
Water based tourism (e.g. camping, tours etc)	Economic development (Future use/returned use)	Waterways, wetlands and waterholes	All year	moderate	All plus security of water entitlement	Original/natural waterway and wetland flows, water quality	
River based tourism	Economic development (Future use/returned use)	River	All year/Seasonal	Strong	baseflows, freshes and bankfull	Original/natural waterway and wetland flows, water quality	Baseflows need to be adequate to allow boat access (i.e. possibly above flow rec). Other flows are to promote general river health
Wetland based tourism	Economic development (Future use/returned use)	Wetlands	All year/Seasonal	Strong	wetting/drying regime, overbank, estuary freshes (salinity)	Original/natural waterway and wetland flows, water quality	
Localised tourism	Economic development (Future use/returned use)	Whole of country	All year/Seasonal	Moderate	Overbank		These are other tourism opportunities not necessarily tied to wetlands to waterways including floodplain waterholes
Aquaculture	Economic development (Future use/returned use)	Near reliable water source	All year	Strong	Security of water entitlement		

What	Value	Where	When	Reliance on water	Flow components	interdependencies	Comments
Aquaculture	Identity	Near reliable water source	All year	Strong	Security of water entitlement		
Aquaculture	Practice-based	Near reliable water source	All year	Strong	Security of water entitlement		
Agriculture	Economic development (Future use/returned use)	Near reliable water source	All year	Moderate	Security of water entitlement		
Agriculture	Identity	Near reliable water source	All year	Moderate	Security of water entitlement		
Agriculture	Practice-based	Near reliable water source	All year	Moderate	Security of water entitlement		
Historic and traditional connection	Relational	Whole of country	All year	Strong	natural regime (water quality)	Original/natural waterway and wetland flows, water quality	Part of this is being able to Read Country based on what has happened in seasons past, and indicators of seasons to come. Continuing to impact any aspect of the original/natural waterway and wetland flows affects the Gunaikurnai's ability to Read Country and subsequently the historic and traditional connection is damaged
Historic and traditional connection	Custodial	Whole of country	All year	Strong	natural regime (water quality)	Original/natural waterway and wetland flows, water quality	Part of this is being able to Read Country based on what has happened in seasons past, and indicators of seasons to come. Continuing to impact any aspect of the original/natural waterway and wetland flows affects the Gunaikurnai's ability to Read Country and subsequently the historic and traditional connection is damaged
Historic and traditional connection	Identity	Whole of country	All year	Strong	natural regime (water quality)	Original/natural waterway and wetland flows, water quality	Part of this is being able to Read Country based on what has happened in seasons past, and indicators of seasons to come. Continuing to impact any aspect of the original/natural waterway and wetland flows affects the Gunaikurnai's ability to Read Country and subsequently the historic and traditional connection is damaged
Bunjil Tambun (fishing)	Affective	Whole of country	Seasonal	Strong	all	Original/natural waterway and wetland flows, water quality	Part of this is being able to Read Country based on what has happened in seasons past, and indicators of seasons to come. Continuing to impact any aspect of the original/natural waterway and wetland flows affects the Gunaikurnai's ability to Read Country and subsequently the historic and traditional connection is damaged
Bunjil Tambun (fishing)	Custodial	Whole of country	Seasonal	Strong	all	Original/natural waterway and wetland flows, water quality	Part of this is being able to Read Country based on what has happened in seasons past, and indicators of seasons to come. Continuing to impact any aspect of the original/natural waterway and wetland flows affects the Gunaikurnai's ability to Read Country and subsequently the historic and traditional connection is damaged
Bunjil Tambun (fishing)	Economic development (Future use/returned use)	Whole of country	Seasonal	Strong	all	Original/natural waterway and wetland flows, water quality	Part of this is being able to Read Country based on what has happened in seasons past, and indicators of seasons to come. Continuing to impact any aspect of the original/natural waterway and wetland flows affects the Gunaikurnai's ability to Read Country and subsequently the historic and traditional connection is damaged
Bunjil Tambun (fishing)	Identity	Whole of country	Seasonal	Strong	all	Original/natural waterway and wetland flows, water quality	Part of this is being able to Read Country based on what has happened in seasons past, and indicators of seasons to come. Continuing to impact any aspect of the original/natural waterway and wetland flows affects the Gunaikurnai's ability to Read Country and subsequently the historic and traditional connection is damaged

What	Value	Where	When	Reliance on water	Flow components	interdependencies	Comments
Bunjil Tambun (fishing)	Place-based	Whole of country	Seasonal	Strong	all	Original/natural waterway and wetland flows, water quality	Part of this is being able to Read Country based on what has happened in seasons past, and indicators of seasons to come. Continuing to impact any aspect of the original/natural waterway and wetland flows affects the Gunaikurnai's ability to Read Country and subsequently the historic and traditional connection is damaged
Bunjil Tambun (fishing)	Practice-based	Whole of country	Seasonal	Strong	all	Original/natural waterway and wetland flows, water quality	Part of this is being able to Read Country based on what has happened in seasons past, and indicators of seasons to come. Continuing to impact any aspect of the original/natural waterway and wetland flows affects the Gunaikurnai's ability to Read Country and subsequently the historic and traditional connection is damaged
Bunjil Tambun (fishing)	Relational	Whole of country	Seasonal	Strong	all	Original/natural waterway and wetland flows, water quality	Part of this is being able to Read Country based on what has happened in seasons past, and indicators of seasons to come. Continuing to impact any aspect of the original/natural waterway and wetland flows affects the Gunaikurnai's ability to Read Country and subsequently the historic and traditional connection is damaged
Bunjil Tambun (fishing)	Social Cohesion	Whole of country	Seasonal	Strong	all	Original/natural waterway and wetland flows, water quality	Part of this is being able to Read Country based on what has happened in seasons past, and indicators of seasons to come. Continuing to impact any aspect of the original/natural waterway and wetland flows affects the Gunaikurnai's ability to Read Country and subsequently the historic and traditional connection is damaged
Bunjil Tambun (fishing)	Well-being	Whole of country	Seasonal	Strong	all	Original/natural waterway and wetland flows, water quality	Part of this is being able to Read Country based on what has happened in seasons past, and indicators of seasons to come. Continuing to impact any aspect of the original/natural waterway and wetland flows affects the Gunaikurnai's ability to Read Country and subsequently the historic and traditional connection is damaged
Woorngan (hunting)	Affective	Whole of country	Seasonal	Moderate	all		Moderate reliance reflects mobility of land animals
Woorngan (hunting)	Custodial	Whole of country	Seasonal	Moderate	all		Moderate reliance reflects mobility of land animals
Woorngan (hunting)	Economic development (Future use/returned use)	Whole of country	Seasonal	Moderate	all		Moderate reliance reflects mobility of land animals
Woorngan (hunting)	Identity	Whole of country	Seasonal	Moderate	all		Moderate reliance reflects mobility of land animals
Woorngan (hunting)	Place-based	Whole of country	Seasonal	Moderate	all		Moderate reliance reflects mobility of land animals
Woorngan (hunting)	Practice-based	Whole of country	Seasonal	Moderate	all		Moderate reliance reflects mobility of land animals
Woorngan (hunting)	Relational	Whole of country	Seasonal	Moderate	all		Moderate reliance reflects mobility of land animals
Woorngan (hunting)	Social Cohesion	Whole of country	Seasonal	Moderate	all		Moderate reliance reflects mobility of land animals
Woorngan (hunting)	Well-being	Whole of country	Seasonal	Moderate	all		Moderate reliance reflects mobility of land animals
Native title	Affective	Native title land (NTL)	varies	Strong	all	Natural regime	How much crown land is there along waterways in Latrobe?
Native title	Custodial	Native title land (NTL)	varies	Strong	all	Natural regime	How much crown land is there along waterways in Latrobe?
Native title	Economic development (Future use/returned use)	Native title land (NTL)	varies	Strong	all	Natural regime	How much crown land is there along waterways in Latrobe?
Native title	Identity	Native title land (NTL)	varies	Strong	all	Natural regime	How much crown land is there along waterways in Latrobe?
Native title	Place-based	Native title land (NTL)	varies	Strong	all	Natural regime	How much crown land is there along waterways in Latrobe?
Native title	Practice-based	Native title land (NTL)	varies	Strong	all	Natural regime	How much crown land is there along waterways in Latrobe?
Native title	Relational	Native title land (NTL)	varies	Strong	all	Natural regime	How much crown land is there along waterways in Latrobe?
Native title	Social Cohesion	Native title land (NTL)	varies	Strong	all	Natural regime	How much crown land is there along waterways in Latrobe?
Native title	Well-being	Native title land (NTL)	varies	Strong	all	Natural regime	How much crown land is there along waterways in Latrobe?

What	Value	Where	When	Reliance on water	Flow components	interdependencies	Comments
RAP access	Affective	Waterways, wetlands and waterholes	varies	Strong	all	Original/natural waterway and wetland flows, water quality	
RAP access	Custodial	Waterways, wetlands and waterholes	varies	Strong	all	Original/natural waterway and wetland flows, water quality	
RAP access	Economic development (Future use/returned use)	Waterways, wetlands and waterholes	varies	Strong	all	Original/natural waterway and wetland flows, water quality	
RAP access	Identity	Waterways, wetlands and waterholes	varies	Strong	all	Original/natural waterway and wetland flows, water quality	
RAP access	Place-based	Waterways, wetlands and waterholes	varies	Strong	all	Original/natural waterway and wetland flows, water quality	
RAP access	Practice-based	Waterways, wetlands and waterholes	varies	Strong	all	Original/natural waterway and wetland flows, water quality	
RAP access	Relational	Waterways, wetlands and waterholes	varies	Strong	all	Original/natural waterway and wetland flows, water quality	
RAP access	Social Cohesion	Waterways, wetlands and waterholes	varies	Strong	all	Original/natural waterway and wetland flows, water quality	
RAP access	Well-being	Waterways, wetlands and waterholes	varies	Strong	all	Original/natural waterway and wetland flows, water quality	
Gathering	Affective	seasonal	Seasonal	Strong	All		
Gathering	Custodial	seasonal	Seasonal	Strong	All		
Gathering	Economic development (Future use/returned use)	seasonal	Seasonal	Strong	All		
Gathering	Identity	seasonal	Seasonal	Strong	All		
Gathering	Place-based	seasonal	Seasonal	Strong	All		
Gathering	Practice-based	seasonal	Seasonal	Strong	All		
Gathering	Relational	seasonal	Seasonal	Strong	All		
Gathering	Social Cohesion	seasonal	Seasonal	Strong	All		
Gathering	Well-being	seasonal	Seasonal	Strong	All		
Alpine water	identity	High country	Seasonal	Strong	n/a		
Alpine water	place-based	High country	Seasonal	Strong	n/a		
Alpine water	custodial	High country	Seasonal	Strong	n/a		
Alpine water	relational	High country	Seasonal	Strong	n/a		
Alpine water	practice	High country	Seasonal	Strong	n/a		
Quarenook (meeting place - Lower Latrobe Wetlands)	Affective	Lower Latrobe Wetlands	All year	Strong	All	Original/natural waterway and wetland flows, water quality	
Quarenook (meeting place - Lower Latrobe Wetlands)	Custodial	Lower Latrobe Wetlands	All year	Strong	All	Original/natural waterway and wetland flows, water quality	
Quarenook (meeting place - Lower Latrobe Wetlands)	Economic development (Future use/returned use)	Lower Latrobe Wetlands	All year	Strong	All	Original/natural waterway and wetland flows, water quality	
Quarenook (meeting place - Lower Latrobe Wetlands)	Identity	Lower Latrobe Wetlands	All year	Strong	All	Original/natural waterway and wetland flows, water quality	
Quarenook (meeting place - Lower Latrobe Wetlands)	Place-based	Lower Latrobe Wetlands	All year	Strong	All	Original/natural waterway and wetland flows, water quality	
Quarenook (meeting place - Lower Latrobe Wetlands)	Practice-based	Lower Latrobe Wetlands	All year	Strong	All	Original/natural waterway and wetland flows, water quality	
Quarenook (meeting place - Lower Latrobe Wetlands)	Relational	Lower Latrobe Wetlands	All year	Strong	All	Original/natural waterway and wetland flows, water quality	

What	Value	Where	When	Reliance on water	Flow components	interdependencies	Comments
Quarenook (meeting place - Lower Latrobe Wetlands)	Social Cohesion	Lower Latrobe Wetlands	All year	Strong	All	Original/natural waterway and wetland flows, water quality	
Quarenook (meeting place - Lower Latrobe Wetlands)	Well-being	Lower Latrobe Wetlands	All year	Strong	All	Original/natural waterway and wetland flows, water quality	
Quarenook (meeting place - other sites)	Affective	Whole of country	All year	Strong	All		
Quarenook (meeting place - other sites)	Custodial	Whole of country	All year	Strong	All		
Quarenook (meeting place - other sites)	Economic development (Future use/returned use)	Whole of country	All year	Strong	All		
Quarenook (meeting place - other sites)	Identity	Whole of country	All year	Strong	All		
Quarenook (meeting place - other sites)	Place-based	Whole of country	All year	Strong	All		
Quarenook (meeting place - other sites)	Practice-based	Whole of country	All year	Strong	All		
Quarenook (meeting place - other sites)	Relational	Whole of country	All year	Strong	All		
Quarenook (meeting place - other sites)	Social Cohesion	Whole of country	All year	Strong	All		
Quarenook (meeting place - other sites)	Well-being	Whole of country	All year	Strong	All		

Appendix A5: Flow recommendations of Reach 4, Tanjil River and Latrobe estuary

Table 29. Latrobe River reach 4 flow recommendations

Flow component	Magnitude (ML/day)	Frequency (No/period)		Duration (days)		Environmental values and functions supported
Summer / Autumn Baseflow	380 or natural	DROUGHT	Cont	DROUGHT	Cont	Supporting healthy country, fishing (Bunjil Tambun) / hunting (Woorngan) and platypus (Balagen), providing pool habitat (adequate depth) to support migratory and resident freshwater fish, macroinvertebrates, aquatic mammals, turtles, and submerged vegetation. Limit terrestrial vegetation encroachment to support emergent macrophyte vegetation. Maintain dissolved oxygen levels in pools (water quality).
		DRY		DRY		
		AVG		AVG		
		WET		WET		
Summer / Autumn Fresh - Water quality	1,400 ML/day	DROUGHT	4	DROUGHT	1 day	Supporting healthy country by flushing sediment (sands) from pools and velocity for pool turnover (water quality and geomorphic processes). This also supports pool habitat for frogs.
		DRY	5	DRY	1 day	
		AVG	6	AVG	1 day	
		WET	6	WET	1 day	
Summer / Autumn Fresh - Fish and Vegetation	1,400 ML/day	DROUGHT	1	DROUGHT	4 days	Supporting healthy country, fishing (Bunjil Tambun) / hunting (Woorngan) and platypus (Balagen). Inundating benches to maintain habitat (geomorphic processes), support growth of emergent macrophyte vegetation and sustain macroinvertebrate and zooplankton communities, and breeding substrate for Blackfish. Longitudinal connectivity for aquatic mammals, migratory fish and estuary residents; including depth over benches for Grayling.
		DRY	2	DRY	3 days	
		AVG	3	AVG	4 days	
		WET	3	WET	5 days	
Winter / Spring Baseflow	1,800 or natural	DROUGHT	Cont	DROUGHT	Cont	Supporting healthy country by providing Summer / Autumn low flow functions plus flushing of sediment (sands) from pools.
		DRY		DRY		
		AVG		AVG		
		WET		WET		
Winter / Spring Fresh	3,000 ML/day	DROUGHT	1	DROUGHT	2 days	Supporting healthy country, fishing (Bunjil Tambun) / hunting (Woorngan) and platypus (Balagen). Inundation over benches (at greater depth) activating ecological processes to provide habitat for macroinvertebrates and zooplankton, providing a food source, habitat and connectivity for resident and estuary resident fish, turtles and frogs. Provide a mosaic of wetted areas for emergent macrophyte vegetation. Inundation of higher benches (geomorphic processes) to improve bench habitat and support growth of riparian vegetation.
		DRY	1	DRY	2 days	
		AVG	3	AVG	2 days	
		WET	4	WET	2 days	
Bankfull	8,000 ML/day	DRT / DRY	-	DRT / DRY	-	Supporting healthy country, canoe trees (Yooro gree). Inundation of riparian vegetation and disturbance of emergent vegetation. Flooding of banks and riparian zone to create nesting conditions for turtles. Maintain channel capacity and bench habitat (geomorphic processes)
		AVG	1/year	AVG	2 days	
		WET		WET		
		Overall: Max duration between events: 2 years				
Overbank	> 10,000 ML/day	DRT / DRY	-	DRT / DRY	-	Supporting healthy country, Fairy wren (Yeerung and Djeetgun), canoe trees (Yooro gree). Inundation of floodplain and riparian vegetation and disturbance of emergent vegetation. This is turn provides habitat for riparian zone birds. Stimulate macroinvertebrate and zooplankton production. Exchange of sediment (and nutrients), and carbon between waterway and floodplain to increase productivity.
		AVG / WET	1/ 2 years	AVG / WET	2 days	
		Overall: Max duration between events: 2 years				

Table 30. Tanjil River reach 8 flow recommendations

Flow component	Magnitude	Frequency (No/period)		Duration (days)		Environmental values and functions supported
Summer / Autumn Baseflow	90 ML/day or natural	DROUGHT	Cont	DROUGHT	Cont	Supporting healthy country, fishing (Bunjil Tambun) / hunting (Woorngan) and platypus (Balagen), providing pool habitat (adequate depth) to support migratory and resident freshwater fish, macroinvertebrates, aquatic mammals, turtles, and submerged vegetation. Limit terrestrial vegetation encroachment to support emergent macrophyte vegetation. Maintain dissolved oxygen levels in pools (water quality).
		DRY		DRY		
		AVG		AVG		
		WET		WET		
Summer / Autumn Fresh	360 ML/day	DROUGHT	1	DROUGHT	3 days	Supporting healthy country, fishing (Bunjil Tambun) / hunting (Woorngan) and platypus (Balagen). Inundating benches to maintain habitat (geomorphic processes), support growth of emergent macrophyte vegetation and sustain macroinvertebrate and zooplankton communities, and breeding substrate for Blackfish. Supporting healthy country by flushing sediment (sands) from pools and velocity for pool turnover (water quality and geomorphic processes). This also supports pool habitat for frogs. Longitudinal connectivity for aquatic mammals, migratory fish and resident freshwater fish.
		DRY	1	DRY	3 days	
		AVG	2	AVG	3 days	
		WET	3	WET	4 days	
Winter / Spring Baseflow	240 ML/day or natural	DROUGHT	Cont	DROUGHT	Cont	Supporting healthy country by providing Summer / Autumn low flow functions plus flushing of sediment (sands) from pools.
		DRY		DRY		
		AVG		AVG		
		WET		WET		
Winter / Spring Fresh	1,100 ML/day	DROUGHT	-	DROUGHT	-	Supporting healthy country, fishing (Bunjil Tambun) / hunting (Woorngan) and platypus (Balagen). Inundation over benches (at greater depth) activating ecological processes to provide habitat for macroinvertebrates and zooplankton, providing a food source, habitat and connectivity for resident and estuary resident fish, turtles and frogs. Provide a mosaic of wetted areas for emergent macrophyte vegetation. Inundation of higher benches (geomorphic processes) to improve bench habitat and support growth of riparian vegetation.
		DRY	1	DRY	2 days	
		AVG	2	AVG	2 days	
		WET	3	WET	2 days	
Bankfull	4,000 ML/day	DRT / DRY	-	DRT / DRY	-	Supporting healthy country, canoe trees (Yooro gree). Inundation of riparian vegetation and disturbance of emergent vegetation. This is turn provides habitat for riparian zone birds. Flooding of banks and riparian zone to create nesting conditions for turtles. Maintain channel capacity and bench habitat (geomorphic processes)
		AVG	1/ 5 years	AVG	1 day	
		WET	1/2 years	WET	1 day	
		Overall: Max duration between events: 4 years				
Overbank	> 5,000 ML/day	DRT / DRY / AVG	-	DRT / DRY / AVG	-	Supporting healthy country, Fairy wren (Yeerung and Djeetgun), canoe trees (Yooro gree). Inundation of floodplain and riparian vegetation and disturbance of emergent vegetation. This is turn provides habitat for riparian zone birds. Stimulate macroinvertebrate and zooplankton production. Exchange of sediment (and nutrients), and carbon between waterway and floodplain to increase productivity.
		WET	1/2 years	WET	1.5 days	
		Overall: Max duration between events: 4 years				

Table 31. Modified flow recommendations for the Latrobe River contribution to the Estuary (i.e. removing Thomson catchment influence)

Flow component	Magnitude at Latrobe above confluence	Frequency (No/period)		Duration (days)	Values and functions supported for Latrobe estuary	Values and functions supported for the Lower Latrobe Wetlands
Summer / Autumn Baseflow	800 ML/day or natural	Cont		Cont	To partially flush in upper portion of water column in the mid estuary Supporting healthy country Provide freshwater above halocline for fish To ensure salinity low enough to support emergent macrophyte vegetation To ensure sufficient velocities to keep fine sediment suspended and transported out of the lower estuary	
Summer / Autumn Fresh 1	1,600 ML/day	DROUGHT	2	7 days	To fully flush the upper portion of the mid estuary and partially flush the upper portion of the lower estuary Supporting healthy country, fishing (Bunjil Tambun) / hunting (Woorngan) Provide freshwater above halocline for fish and freshwater conditions for birds	To ensure there is wetland watering (partial fill) to encourage fish reproduction, promote growth and flowering for submerged and emergent vegetation and wetland watering (fill) to discourage undesirable or invasive plant species (prolong inundation)
		DRY	2	10 days		
		AVG	3	10 days		
		WET	3	10 days		
Summer / Autumn Fresh 2	2,300 ML/day	DROUGHT	1	4 days	To fully flush both mid estuary and upper portion of the lower estuary Supporting healthy country, provide freshwater in mid estuary area for wetland watering (Sale Common, western and central Heart Morass structures, western Dowd Morass)	To ensure wetland watering (partial fill) to promote growth and flowering for submerged and emergent vegetation
		DRY	1	7 days		
		AVG	1	10 days		
		WET	2	10 days		
Winter / Spring Baseflow	800 ML/day	Cont		Cont	To partially flushed the upper portion of water column Provide freshwater above halocline for fish To ensure salinity low enough to support emergent macrophyte vegetation To ensure sufficient velocities to keep fine sediment suspended and transported out of the lower estuary	
Winter / Spring Fresh 1	2,300 ML/day	DROUGHT	2	5 days	To fully flush mid estuary and upper portion of the lower estuary Supporting healthy country, canoe trees (Yooro gree), freshwater for wetlands	Wetland watering (partial fill and fill) to stimulate bird breeding, nesting through flooding of banks and riparian zone, foraging activities and food supply, encourage spawning for Black Beam and fish reproduction, provide littoral habitat for frogs, inundating
		DRY	2	10 days		
		AVG	3	15 days		

Flow component	Magnitude at Latrobe above confluence	Frequency (No/period)		Duration (days)	Values and functions supported for Latrobe estuary	Values and functions supported for the Lower Latrobe Wetlands
		WET	3	20 days	Provide freshwater conditions above halocline for fish Provide freshwater conditions for frogs and birds Freshwater in mid estuary area for wetland watering (Sale Common, western and central Heart Morass structures, western Dowd morass) Flushing silts Mosaic of wetted areas for emergent and riparian vegetation.	fringing vegetation to encourage water birds to forage, growth and reproduction of macroinvertebrate communities as food source, provide connectivity between river and wetland and between wetlands, promote growth and flowering for submerged and emergent vegetation, encourage inundation for fringing wetland vegetation
Winter / Spring Fresh 2	3,000 ML/day	DROUGHT	1	10 days	To ensure mid and lower estuary fully flushed Support growth of Phragmites in lower estuary during Spring Salinity gradient for Grayling	
		DRY	1	15 days		
		AVG	2	20 days		
		WET	2	30 days		
Bankfull	5,500	DRY	1	4 days	Supporting healthy country, canoe tress (Yooro gree) Inundation of riparian vegetation and disturbance to support emergent vegetation Displace salt wedge into Lake Wellington to limit surface water salinity to enable growth and reproduction (seed and propagule dispersal) of emergent vegetation, submerged aquatic macrophyte and fringing vegetation Maintain channel capacity (geomorphic process)	Wetland watering (fill) to provide connectivity and movement, flooding of banks and riparian zone to create conditions for nesting
		AVG	2	5 days		
		WET	2	8 days		
		Overall: Max duration between events: 2 years				
Overbank	7,500	AVG	1/ 2 years	3 days	Supporting healthy country. Inundation and seed dispersal for floodplain and riparian vegetation Riparian vegetation then provides habitat for riparian zone birds Stimulate macroinvertebrate and zooplankton production Exchange of sediment (and nutrients), and carbon between waterway and floodplain to increase productivity	Wetland watering (fill) to stimulate bird breeding, nesting, foraging activities and food supply, inundating fringing vegetation to encourage water birds to forage, inundating floodplain and riparian vegetation for seed dispersal and provide habitat for riparian zone birds Wetland watering (flushing flows) to support fish migration into and between wetlands and into river, and inundating of fringing wetland vegetation
		WET	1	5 days		
		Overall: Max duration between events: 5 years				

Approach to performance
The performance assessment evaluates how well the scenarios perform against the environmental flow recommendations.

The tool for assessing performance is eFlow Projector that analyses the daily time series flow record for the prescribed season for each flow rule and creates a success score against the different components of the flow regime (magnitude, duration, count, independence). These component scores are aggregated by taking the minimum component score for the flow rule for the season.

The performance assessment also accommodated the requirements for prescribed seasons by identifying the type of climatic condition in each year (e.g. drought, dry, average or wet) and calculating the component scores for those climatic conditions. For multi-year flow events such as Bankfull or Overbank where flow recommendations may require a flow events within a certain number of years (e.g. 1 in 4 years), eFlow Projector looks back at flow series in the previous years (e.g. 4 years) to see if the flow event has been met before calculating a score for the previous years within the time frame (e.g. 4 years).

There are two general types of flow components for this performance assessment:

- Low Flows / Baseflows, where the score considers the total duration of flow equal or above a flow threshold within a prescribed season, relative to the number of days required to meet the recommendation in full. For example, if a baseflow requires flow to be above a specific magnitude for every day in a 180-day season, but the flow record shows only 135 days exceeding that magnitude, then the resulting environmental flow recommendations performance score would be 75% (i.e. 135/180).
- Freshes, where the score represents the success of achieving the target magnitude, duration, number of events in the season, and independence period between events.

Once all component scores are aggregated, the summary score is between 0% and 100% for each flow component, in each reach, for each water year:

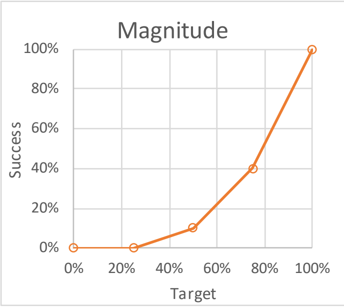
- 0% indicates that the flow recommendation was never achieved in that water year
- 100% indicates that the environmental flow recommendations were achieved in full during that water year.

Note that a score of 1 (100%) for all flow components in every year is not expected under any scenario, even the unimpacted scenario. The environmental flow recommendations represent flow components in a simplified way to ensure that environmental objectives can be met, while being aligned with the unimpacted flow regime. The unimpacted flows are inherently more variable (both between and within years) than the flow recommendations.

Partial success
The performance assessment considers the partial success across magnitude, duration, number of events and independence of events within a flow rule, which traditionally would have been considered as either a pass or fail. It allows users to create a continuous function to define success for each flow component, as illustrated in Figure 19. In the example below, if the flow magnitude was 50% of the target flow threshold, then a success score of 10% would be applied to the magnitude component for that day.

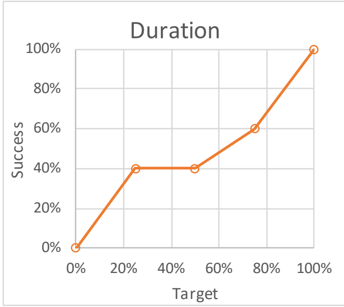
Magnitude

Target	Success
0%	0%
25%	0%
50%	10%
75%	40%
100%	100%



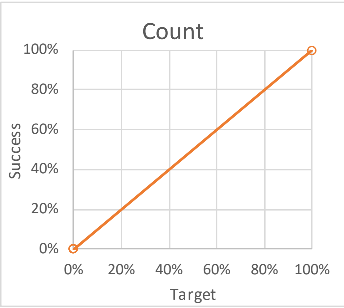
Duration

Target	Success
0%	0%
25%	40%
50%	40%
75%	60%
100%	100%



Count

Target	Success
0%	0%
0%	0%
0%	0%
0%	0%
100%	100%



Independence

Target	Success
0%	0%
0%	0%
0%	0%
0%	0%
100%	100%

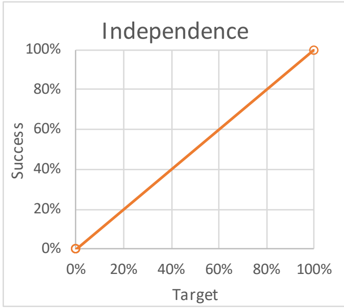


Figure 19. *Example of partial success setting for freshes*

The performance assessment adopted the partial success values that were developed for Victorian Environmental Water Holder (VEWH) for their environmental flow reporting work. These values were validated against the habitat preference curves developed in Alluvium (2020) for the main reaches of Latrobe River system and were deemed suitable for use in this performance assessment (Table 32)

Table 32. Partial success values for flow components for all reaches

Flows	Magnitude		Duration		Count		Independence	
	Target	*Success*	*Target*	*Success*	*Target*	*Success*	*Target*	*Success*
Freshes	0%	0%	0%	0%	0%	0%	0%	0%
	25%	0%	25%	40%	0%	0%	0%	0%
	50%	10%	50%	40%	0%	0%	0%	0%
	75%	40%	75%	60%	0%	0%	0%	0%
	100%	100%	100%	100%	100%	100%	100%	100%
Baseflow	0%	0%	0%	0%				
	25%	0%	0%	0%				
	50%	20%	0%	0%				
	75%	60%	0%	0%				
	100%	100%	100%	100%				

Appendix B. Risk assessment – full results

Appendix B1: Performance scores

The performance scores for the key scenarios are as follows.

Table 33. Annual average performance scores against flow recommendations, post-1975 historic climate reference period. Changes from baseline greater than 5% shown in brackets.

Location	Flow components	Baseline	Scenario 1	Scenario 2	Scenario 3	Scenario 4	Scenario 5
Latrobe River (Reach 4)	Summer / Autumn Baseflow	97%	96%	96%	96%	96%	96%
	Summer / Autumn Fresh 1	62%	55% (↓7%)	64% (-)	74% (↑12%)	74% (↑12%)	72% (↑10%)
	Summer / Autumn Fresh 2	83%	78% (↓5%)	84% (-)	91% (↑8%)	91% (↑8%)	90% (↑7%)
	Winter / Spring Baseflow	68%	62%(↓6%)	68%	69%	69%	68%
	Winter / Spring Fresh	95%	95%	95%	95%	95%	95%
	Bankfull	79%	77%	79%	78%	78%	77%
	Overbank	86%	84%	86%	85%	85%	84%
Latrobe River Estuary	Summer / Autumn Baseflow	65%	59% (↓7%)	62%	67%	68%	67%
	Summer / Autumn Fresh 1	58%	53% (↓5%)	58%	64% (↑6%)	64% (↑6%)	64% (↑6%)
	Summer / Autumn Fresh 2	62%	56% (↓5%)	62%	66% (↑5%)	66% (↑5%)	65% (↑5%)
	Winter / Spring Baseflow	91%	87%	91%	93%	93%	93%
	Winter / Spring Fresh 1	81%	79%	81%	82%	82%	81%
	Winter / Spring Fresh 2	76%	71%	76%	73%	73%	72%
	Bankfull	79%	76%	80%	78%	78%	76%
	Overbank	91%	89%	91%	90%	90%	89%
Tanjil River (Reach 8)	Summer / Autumn Baseflow	98%	98%	98%	98%	98%	98%
	Summer / Autumn Fresh	98%	96%	98%	95%	96%	94%
	Winter / Spring Baseflow	52%	45% (↓7%)	54%	83% (↑31%)	82% (↑30%)	77% (↑25%)
	Winter / Spring Fresh	83%	77% (↓6%)	84%	78%(↓6%)	78% (↓6%)	77% (↓6%)
	Bankfull	70%	59% (↓11%)	70%	67%	67%	58% (↓12%)
	Overbank	48%	41% (↓7%)	48%	46%	46%	41% (↓7%)

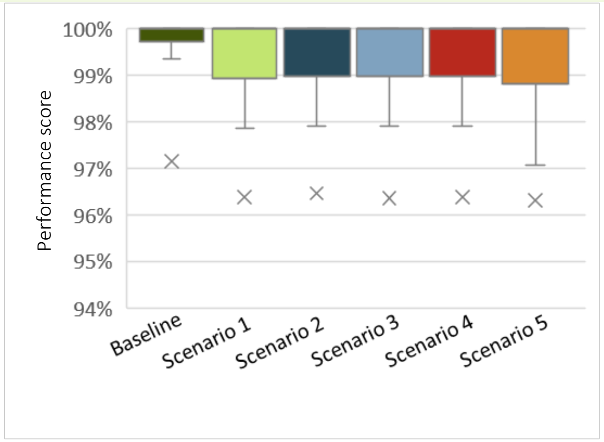
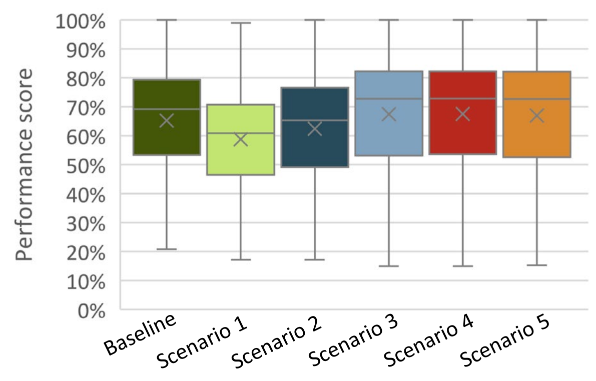
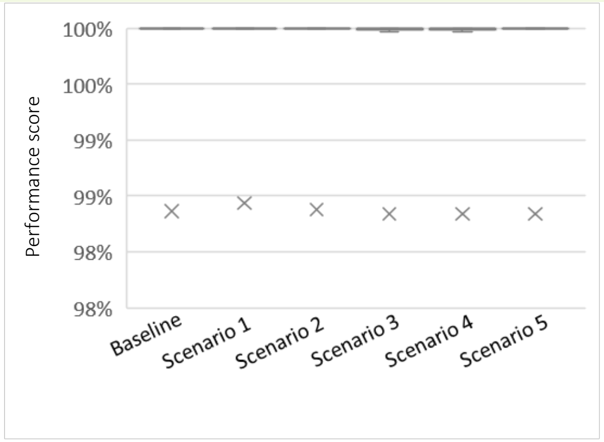
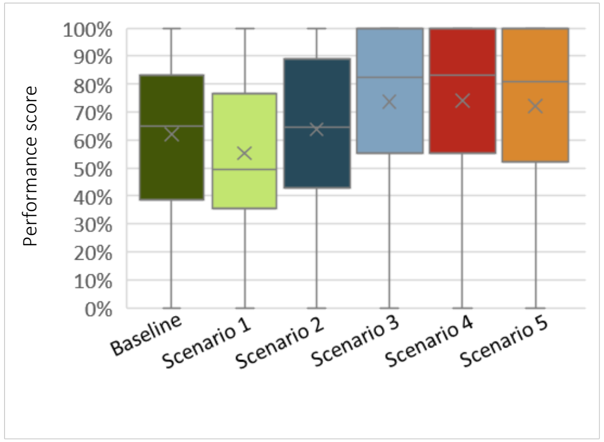
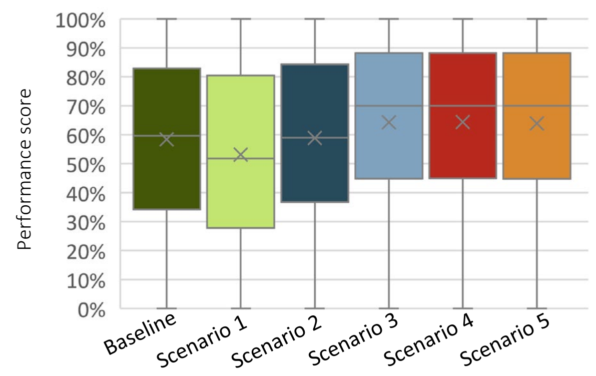
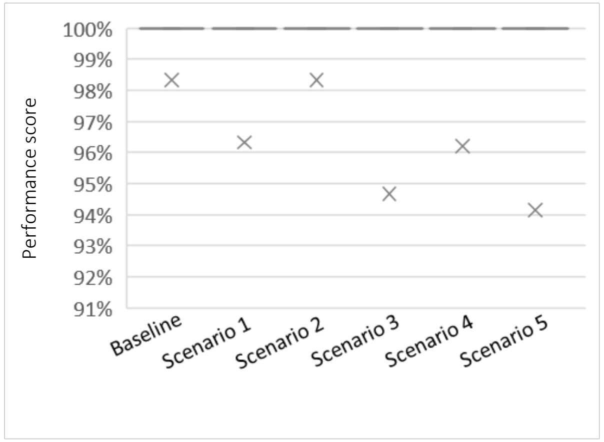
Table 34. Annual average performance scores against flow recommendations, medium climate change conditions

Location	Flow components	Baseline	Scenario 1	Scenario 2	Scenario 3	Scenario 4	Scenario 5
Latrobe River (Reach 4)	Summer / Autumn Baseflow	81%	95%	94%	94%	94%	94%
	Summer / Autumn Fresh 1	40%	54%	48%	55%	58%	58%
	Summer / Autumn Fresh 2	54%	73%	65%	73%	79%	79%
	Winter / Spring Baseflow	43%	59%	53%	59%	62%	62%
	Winter / Spring Fresh	86%	94%	92%	94%	93%	93%
	Bankfull	44%	70%	69%	71%	70%	70%
	Overbank	41%	75%	72%	75%	74%	74%
Latrobe River Estuary	Summer / Autumn Baseflow	36%	56%	50%	53%	57%	57%
	Summer / Autumn Fresh 1	30%	46%	40%	47%	53%	53%
	Summer / Autumn Fresh 2	32%	48%	42%	49%	54%	53%
	Winter / Spring Baseflow	81%	89%	84%	88%	91%	91%
	Winter / Spring Fresh 1	58%	76%	73%	76%	78%	78%
	Winter / Spring Fresh 2	40%	65%	61%	65%	64%	65%
	Bankfull	44%	69%	68%	70%	70%	70%
	Overbank	51%	83%	81%	83%	83%	83%
Tanjil River (Reach 8)	Summer / Autumn Baseflow	98%	98%	98%	98%	98%	98%
	Summer / Autumn Fresh	97%	95%	96%	88%	89%	86%
	Winter / Spring Baseflow	40%	36%	41%	81%	79%	72%
	Winter / Spring Fresh	77%	67%	78%	72%	74%	68%
	Bankfull	50%	34%	52%	47%	49%	26%
	Overbank	33%	21%	34%	29%	32%	13%

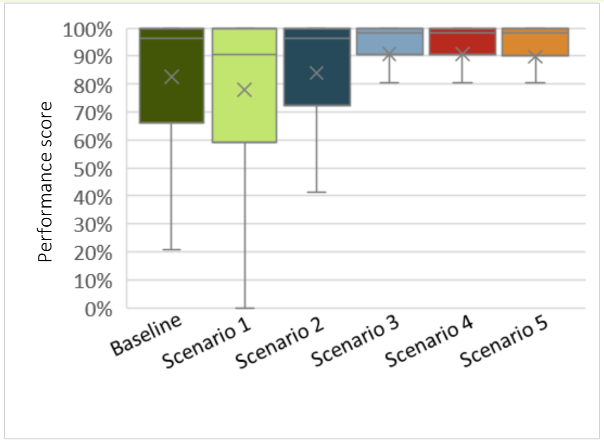
Table 35. Annual average performance scores against flow recommendations, 2065high climate change conditions

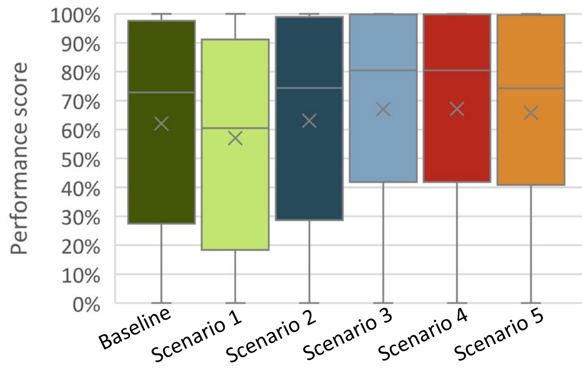
Location	Flow components	Baseline	Scenario 1	Scenario 2	Scenario 3	Scenario 4	Scenario 5
Latrobe River (Reach 4)	Summer / Autumn Baseflow	86%	80%	81%	81%	81%	81%
	Summer / Autumn Fresh 1	32%	29%	33%	38%	38%	38%
	Summer / Autumn Fresh 2	44%	38%	45%	54%	54%	53%
	Winter / Spring Baseflow	39%	34%	39%	43%	43%	43%
	Winter / Spring Fresh	84%	83%	84%	85%	85%	85%
	Bankfull	44%	42%	44%	44%	44%	43%
	Overbank	41%	40%	42%	41%	41%	40%
Latrobe River Estuary	Summer / Autumn Baseflow	37%	31%	34%	36%	36%	36%
	Summer / Autumn Fresh 1	25%	21%	25%	29%	29%	29%
	Summer / Autumn Fresh 2	27%	23%	27%	32%	32%	32%
	Winter / Spring Baseflow	77%	70%	75%	80%	80%	80%
	Winter / Spring Fresh 1	54%	50%	55%	58%	58%	57%
	Winter / Spring Fresh 2	39%	35%	39%	40%	40%	39%
	Bankfull	44%	41%	44%	44%	44%	43%
	Overbank	53%	50%	53%	52%	52%	50%
Tanjil River (Reach 8)	Summer / Autumn Baseflow	97%	94%	98%	97%	97%	97%
	Summer / Autumn Fresh	86%	86%	83%	55%	55%	53%
	Winter / Spring Baseflow	27%	26%	25%	65%	65%	54%
	Winter / Spring Fresh	39%	31%	48%	45%	44%	46%
	Bankfull	12%	10%	14%	3%	3%	4%
	Overbank	5%	4%	6%	1%	1%	1%

Table 36. Performance scores against flow recommendations, presented as box plots, post-1975 historic climate reference period conditions

	Latrobe River Reach 4	Latrobe River estuary	Tanjil River
Summer / Autumn baseflows			
Summer / Autumn Freshes	 Fresh 1 – Water Quality	 Fresh 1	

	Latrobe River Reach 4	Latrobe River estuary	Tanjil River

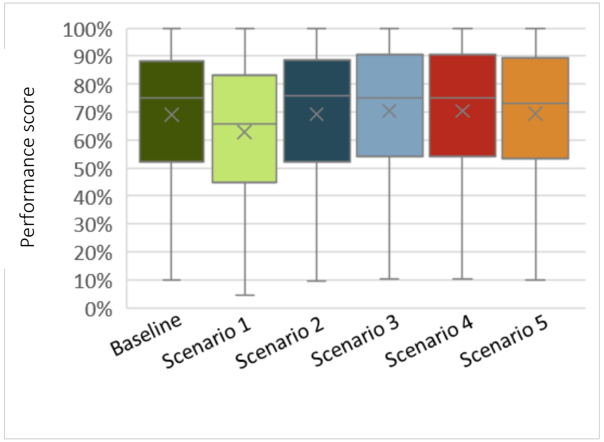


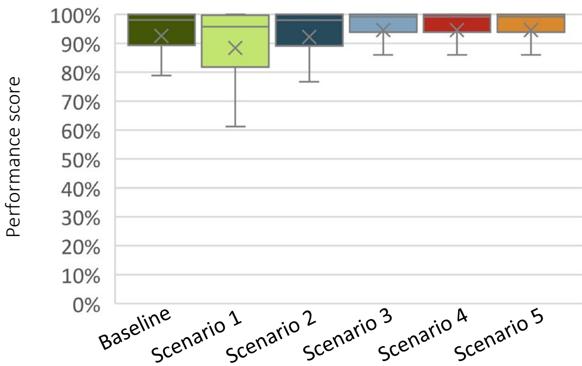


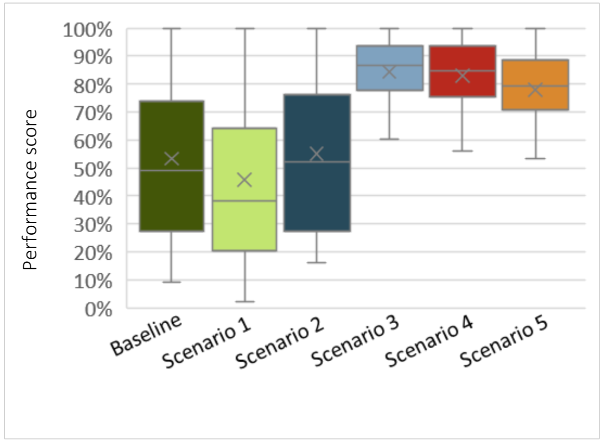
Fresh 2 – Fish and vegetation

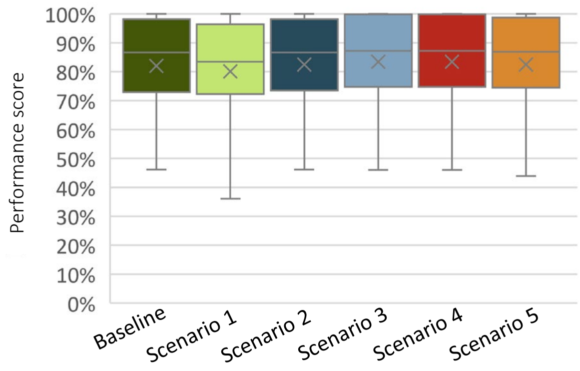
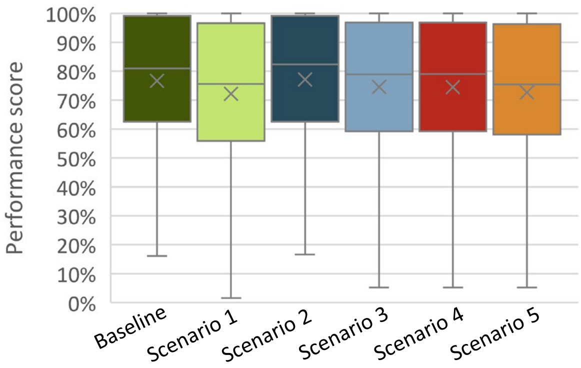
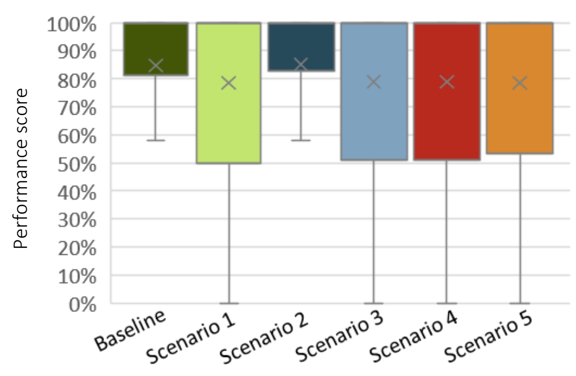
Fresh 2

Winter / Spring baseflow



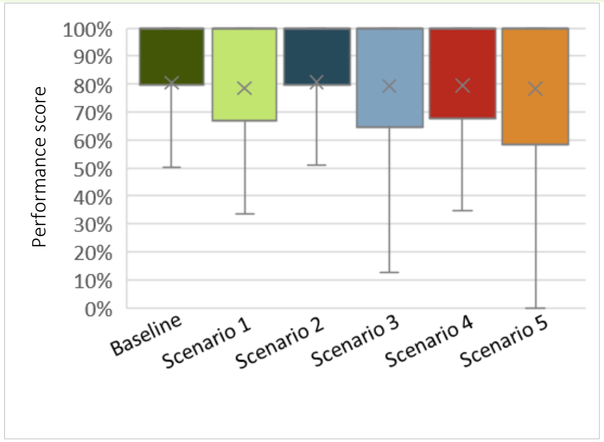


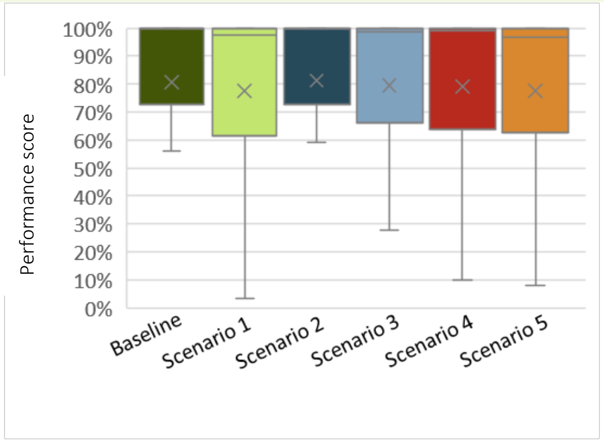


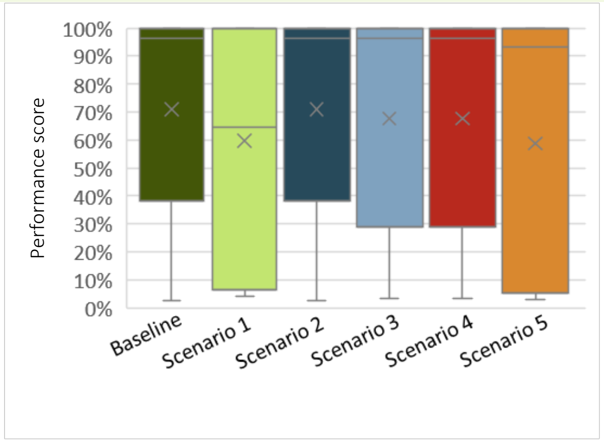
	Latrobe River Reach 4	Latrobe River estuary	Tanjil River
Winter / Spring Fresh		 Fresh 1  Fresh 2	

	Latrobe River Reach 4	Latrobe River estuary	Tanjil River

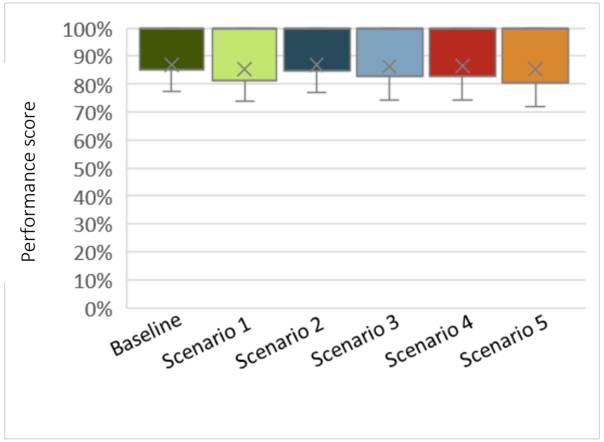
Bankfull

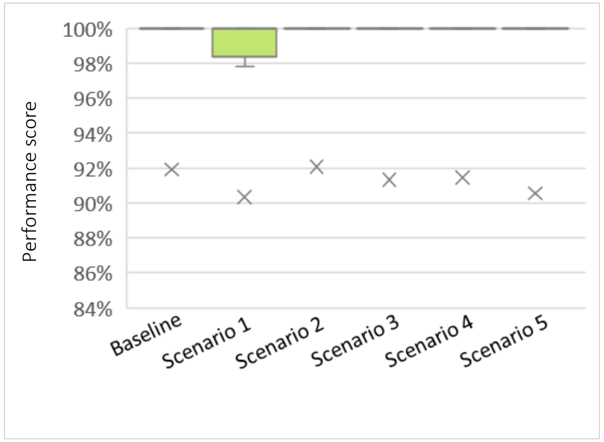






Overbank





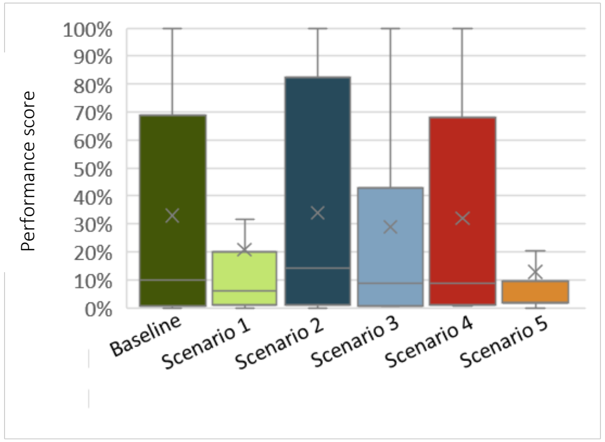
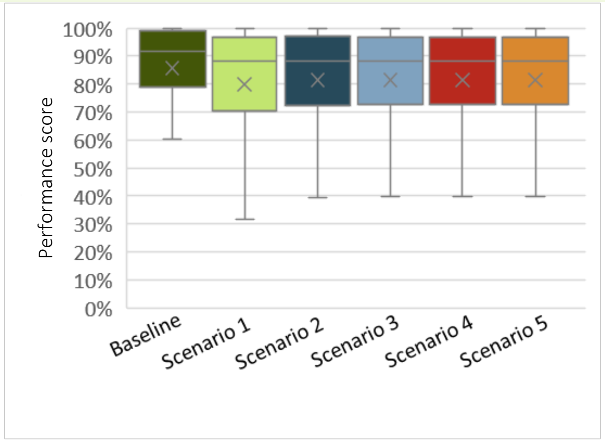
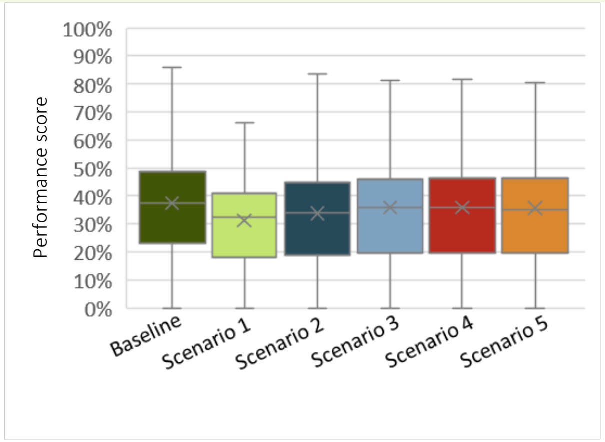
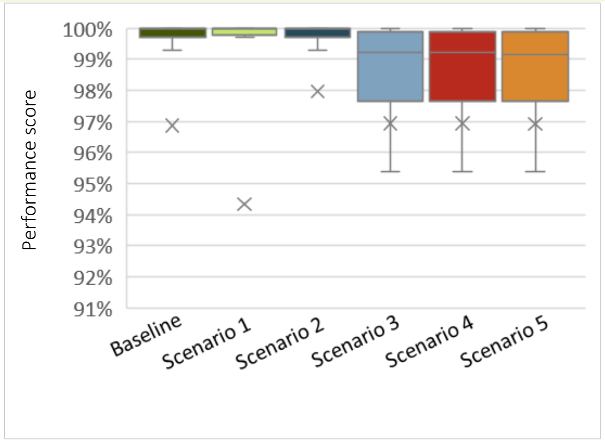
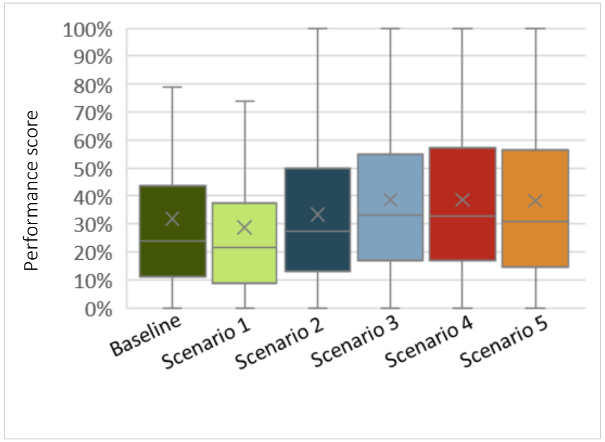


Table 37. Performance scores against flow recommendations, presented as box plots, 2065 high climate change conditions

<table>
<tr><th></th><th>Latrobe River Reach 4</th><th>Latrobe estuary</th><th>Tanjil River</th></tr>
<tr><td>Summer / Autumn baseflows</td>
<td></td>
<td></td>
<td></td></tr>
<tr><td>Summer / Autumn Freshes</td>
<td>
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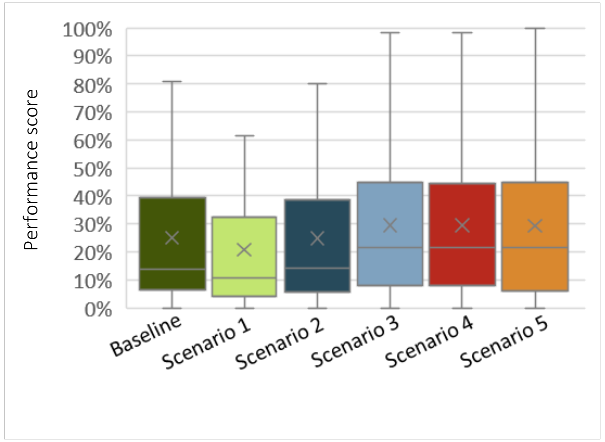
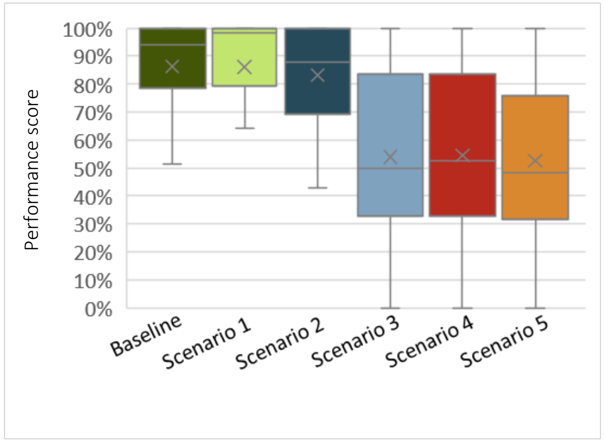
<td>
Fresh 1</td>
<td></td></tr>
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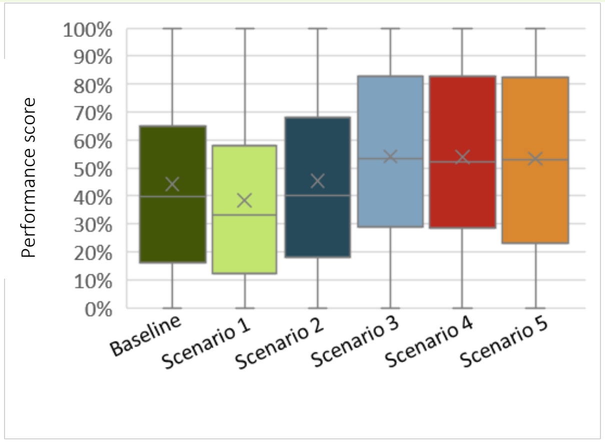
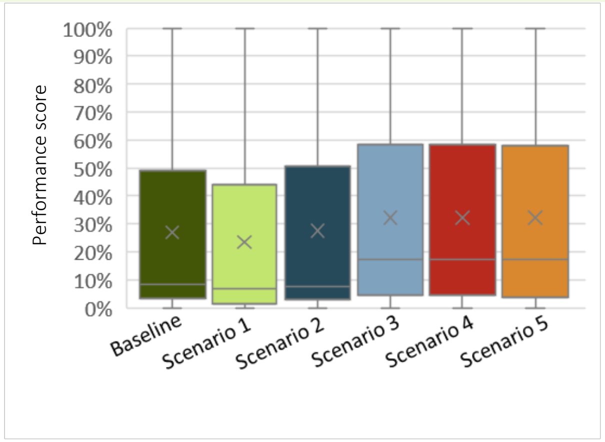
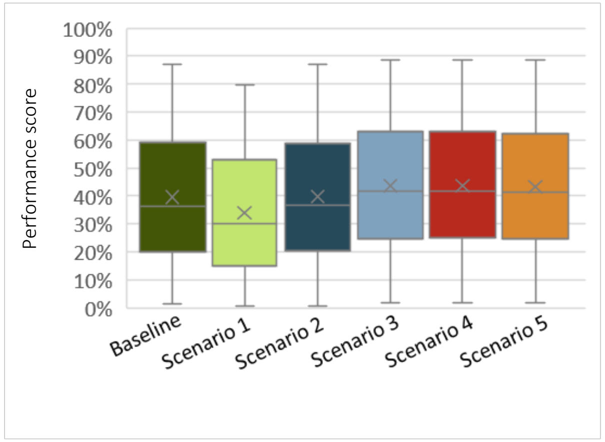
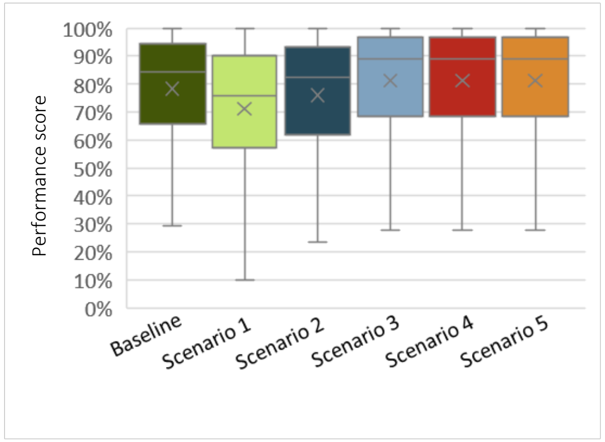
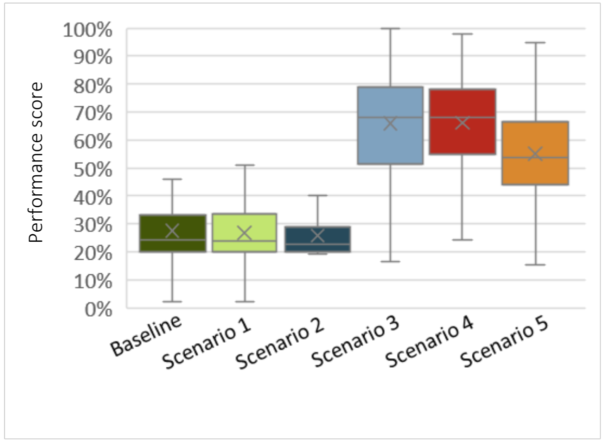
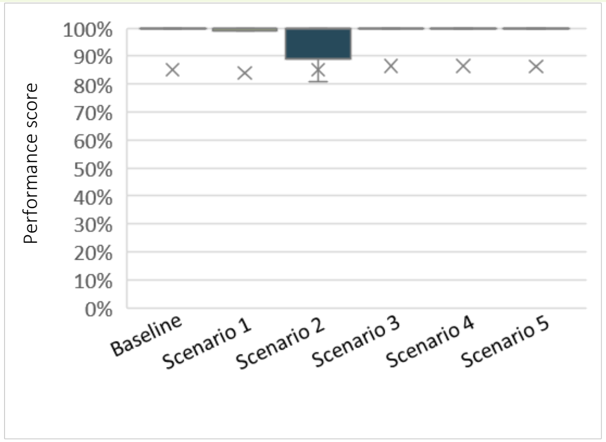
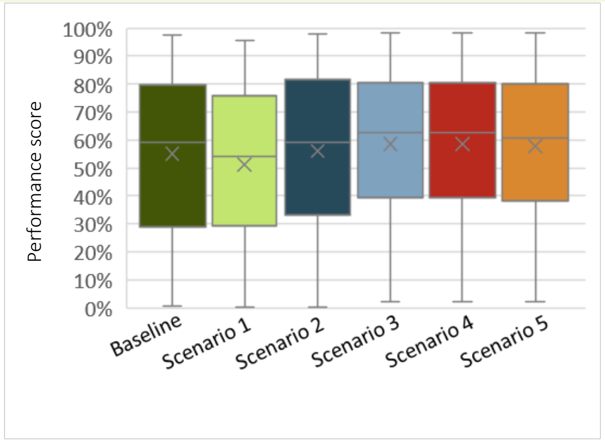
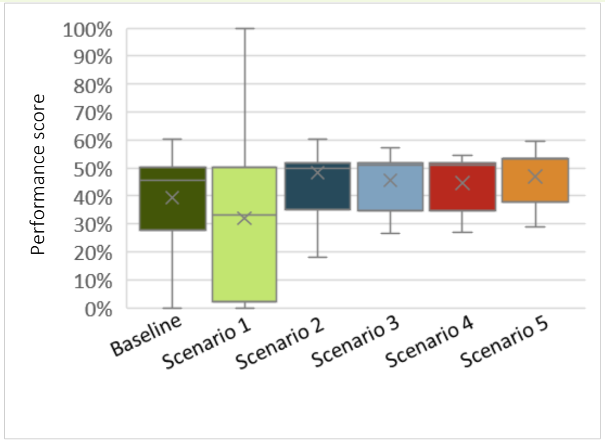
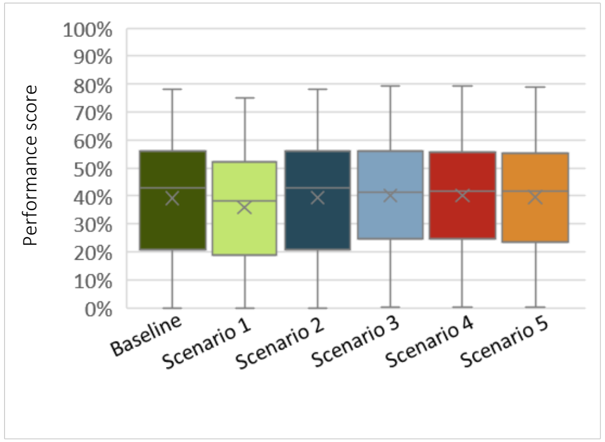
	Latrobe River Reach 4	Latrobe estuary	Tanjil River
			
	Fresh 2 – Fish and vegetation	Fresh 2	
Winter / Spring Baseflow			

	Latrobe River Reach 4	Latrobe estuary	Tanjil River
Winter / Spring Fresh			

Fresh 1



Fresh 2

	Latrobe River Reach 4	Latrobe estuary	Tanjil River

Bankfull

Overbank

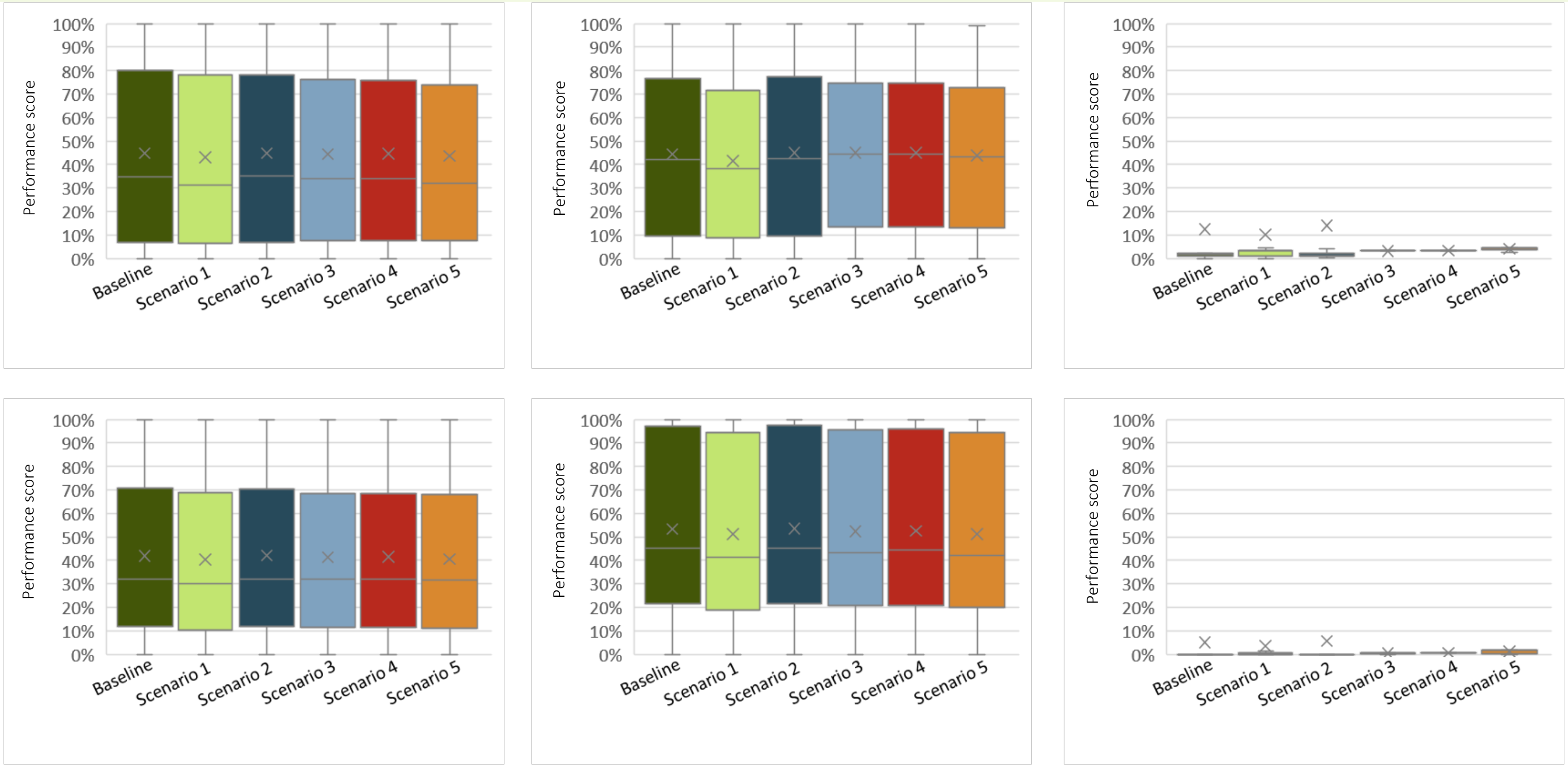
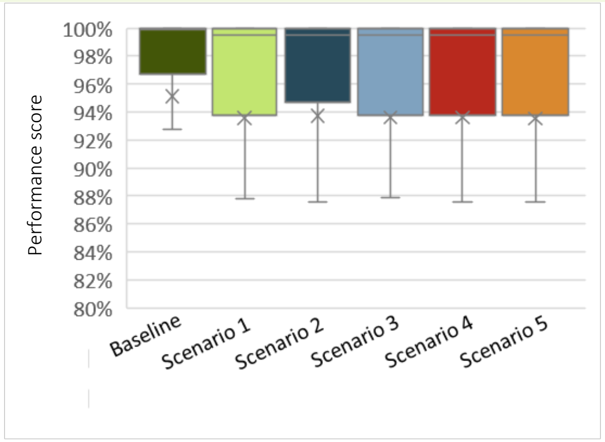
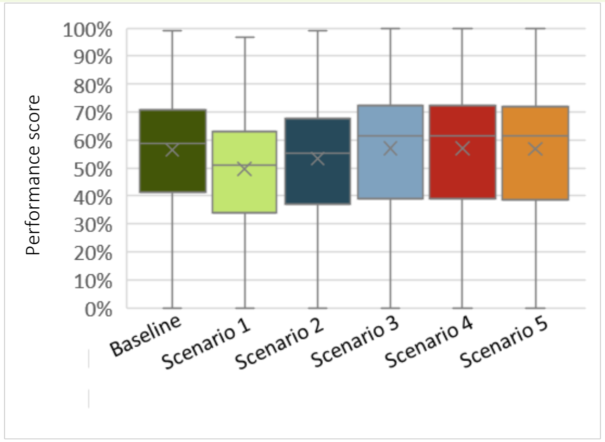
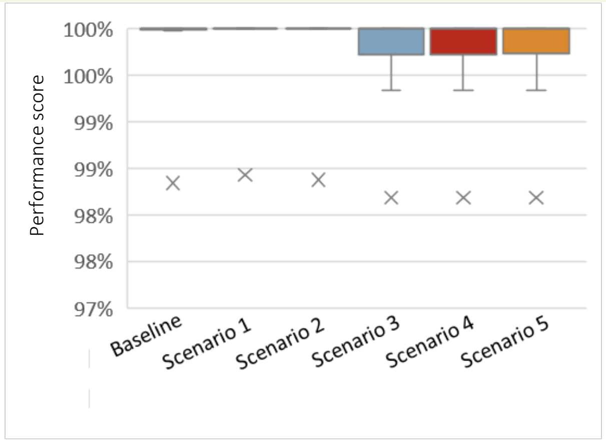
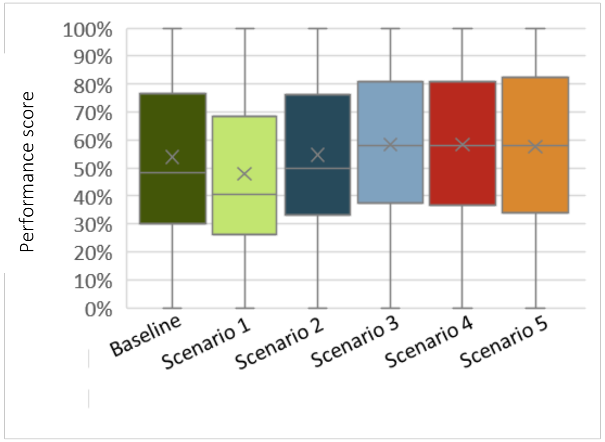
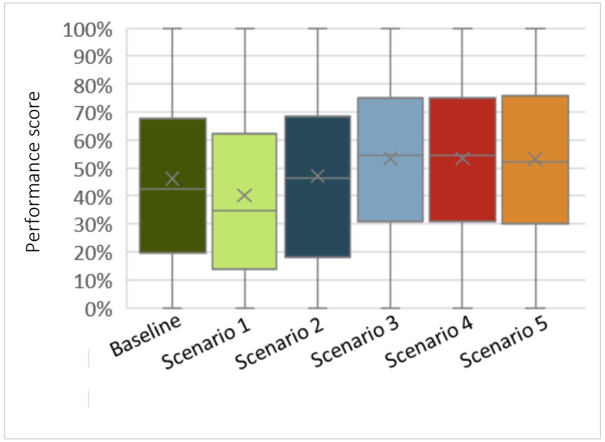
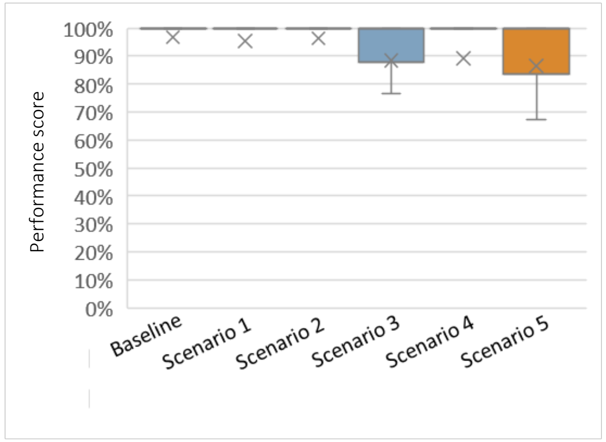
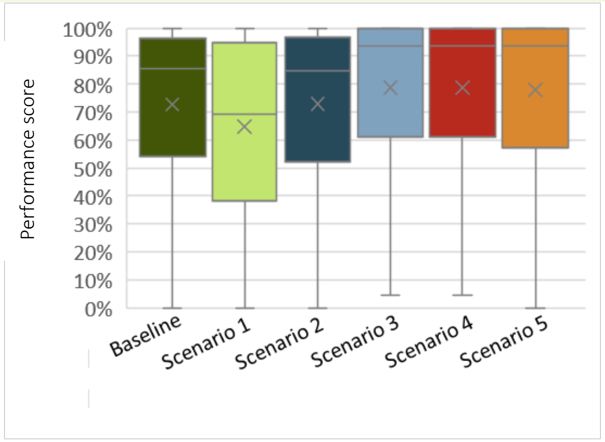


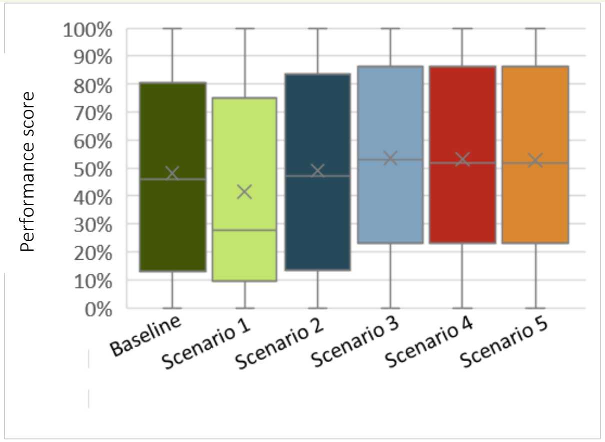
Table 38. Performance scores against flow recommendations, presented as box plots, 2065 medium climate change conditions

	Latrobe River Reach 4	Latrobe River estuary	Tanjil River
Summer / Autumn baseflows			
Summer / Autumn Freshes			
	Fresh 1 – Water Quality	Fresh 1	

	Latrobe River Reach 4	Latrobe River estuary	Tanjil River

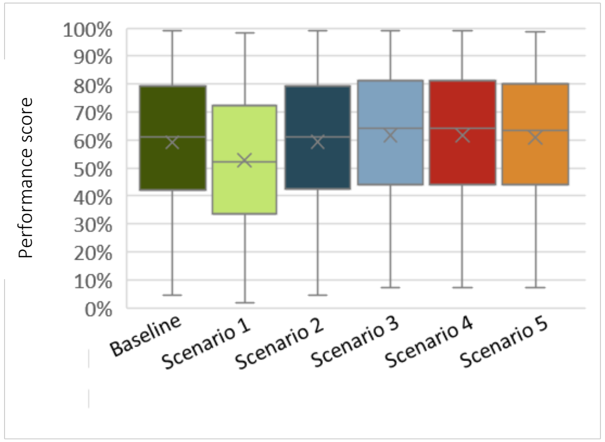


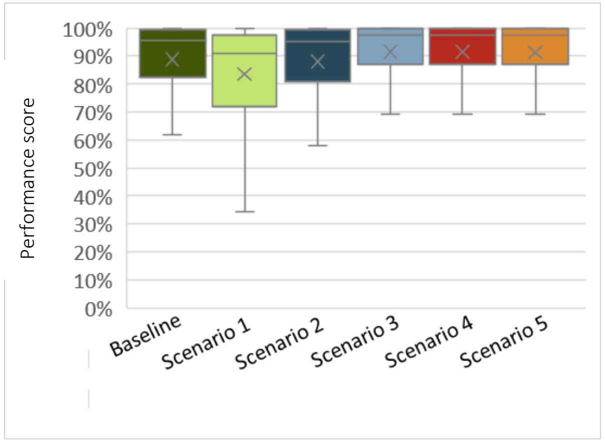
Fresh 2 – Fish and vegetation

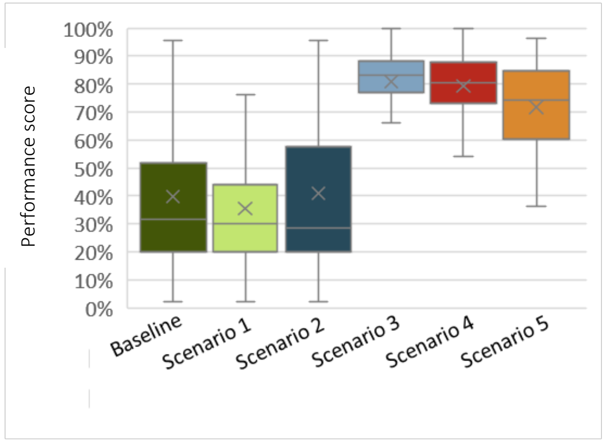


Fresh 2

Winter / Spring Baseflow

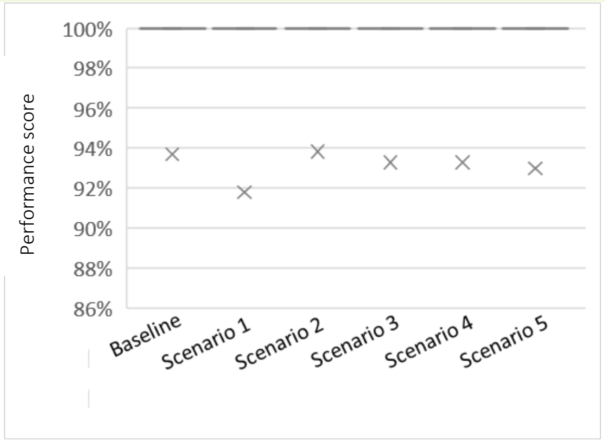




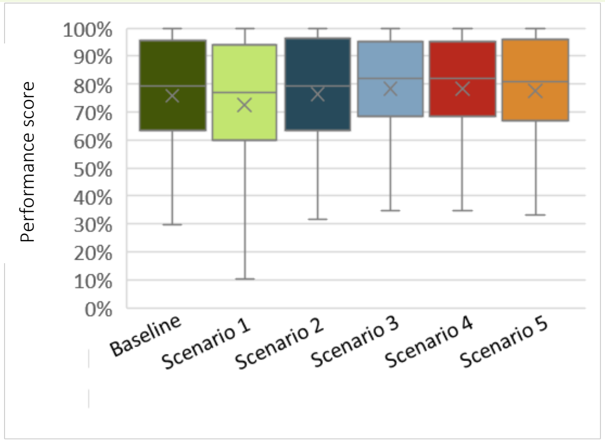


Winter / Spring Fresh

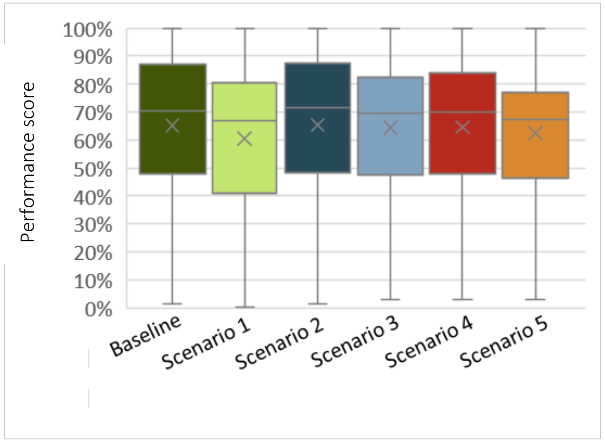
Latrobe River Reach 4



Latrobe River estuary

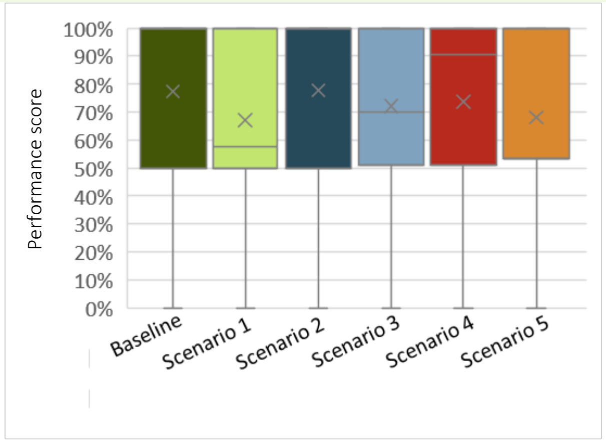


Fresh 1



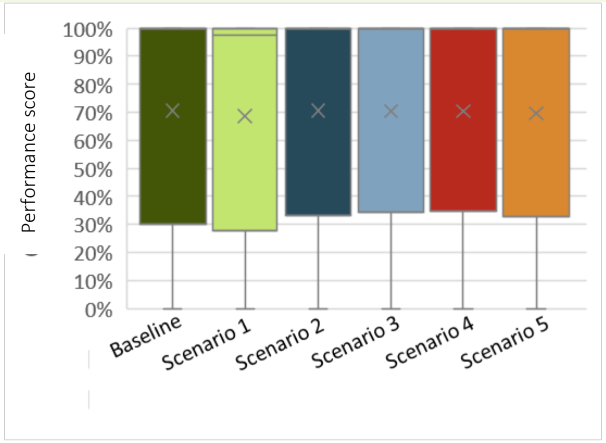
Fresh 2

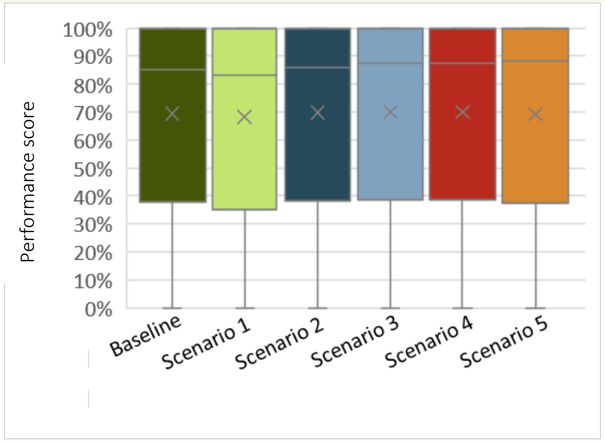
Tanjil River

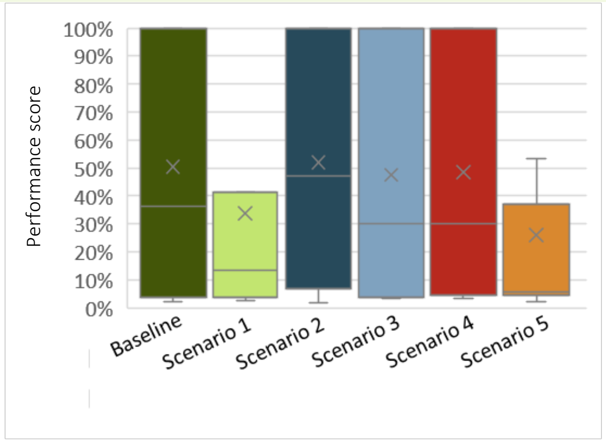


	Latrobe River Reach 4	Latrobe River estuary	Tanjil River

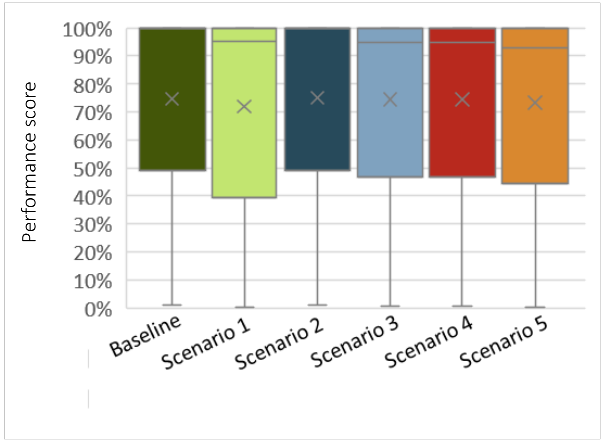
Bankfull

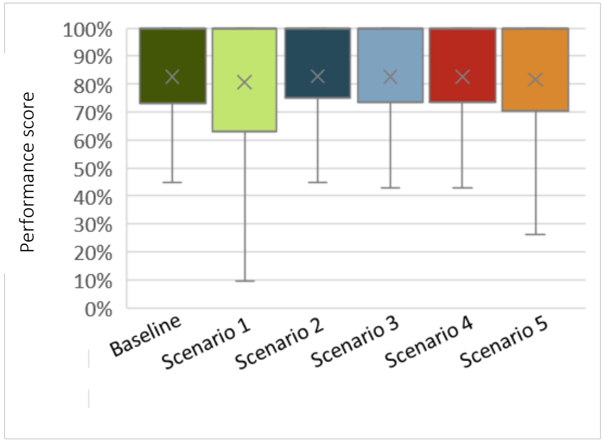


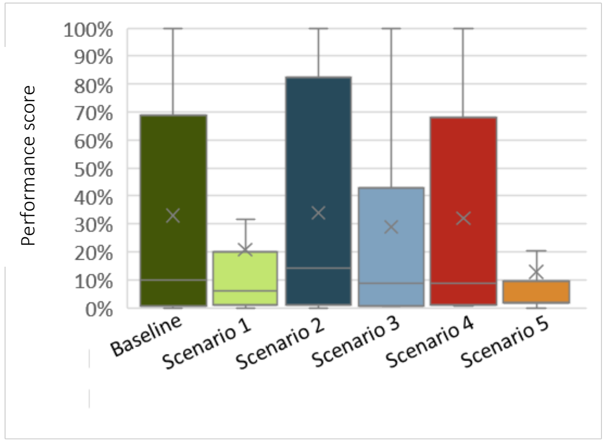




Overbank





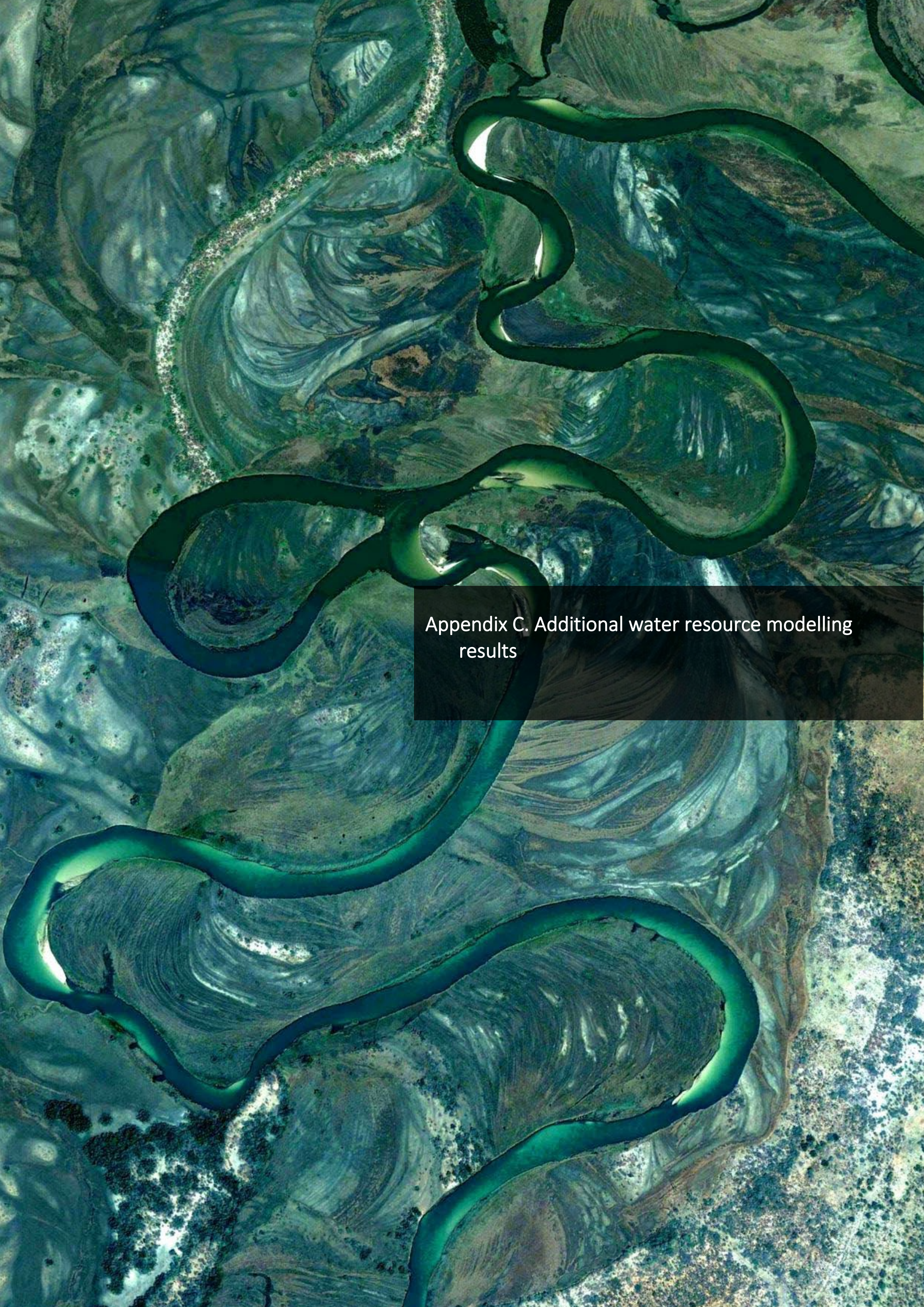


Appendix B2: Risk scores

Table 39. Risk assessment ratings for all scenarios over the post-1975 historic climate reference period

	Environmental value	Maximum risk under Baseline I	Maximum risk under Scenario 1	Maximum risk under Scenario 2	Maximum risk under Scenario 3	Maximum risk under Scenario 4	Maximum risk under Scenario 5
Latrobe River Reach 4	Vegetation – submerged & emergent	Medium	Medium	Medium	Medium	Medium	Medium
	Vegetation – riparian & floodplain	Medium	Medium	Medium	Medium	Medium	Medium
	Fish	High	High	High	High	High	High
	Birds	Low	Low	Low	Low	Low	Low
	Aquatic mammals	High	High	High	High	High	High
	Frogs	Medium	Significant	Medium	Medium	Medium	Medium
	Turtles	Medium	Medium	Medium	Medium	Medium	Medium
Latrobe River estuary	Vegetation – submerged & emergent	High	High	High	High	High	High
	Vegetation – riparian & floodplain	Significant	Significant	Significant	Significant	Significant	Significant
	Fish	High	High	High	High	High	High
	Birds	High	High	High	Significant	Significant	Significant
	Frogs	Medium	Medium	Medium	Medium	Medium	Medium
	Turtles	Medium	Medium	Medium	Medium	Medium	Medium
Tanjil River	Vegetation – submerged & emergent	Medium	Medium	Medium	Medium	Medium	Medium
	Vegetation – riparian & floodplain	Significant	Significant	Significant	Significant	Significant	Significant
	Fish	Significant	Significant	Significant	Medium	Medium	Medium
	Birds	Medium	Medium	Medium	Medium	Medium	Medium
	Aquatic mammals	Significant	Significant	Significant	Medium	Medium	Medium
	Frogs	Medium	Medium	Medium	Medium	Medium	Medium
	Turtles	Medium	Medium	Medium	Medium	Medium	Medium

Appendix C. Additional water resource modelling results



Appendix C1: Supply for mine rehabilitation

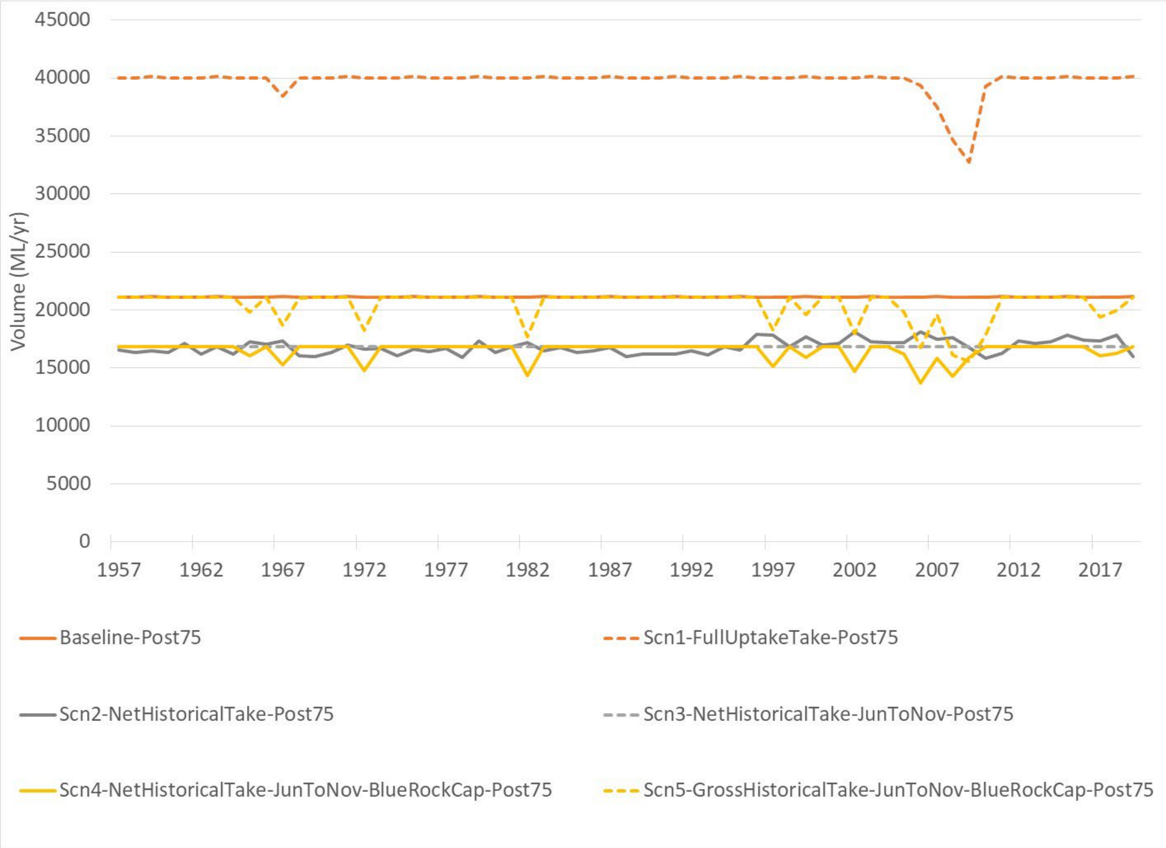


Figure 20 Annual supply for mine rehabilitation from Loy Yang A bulk entitlement

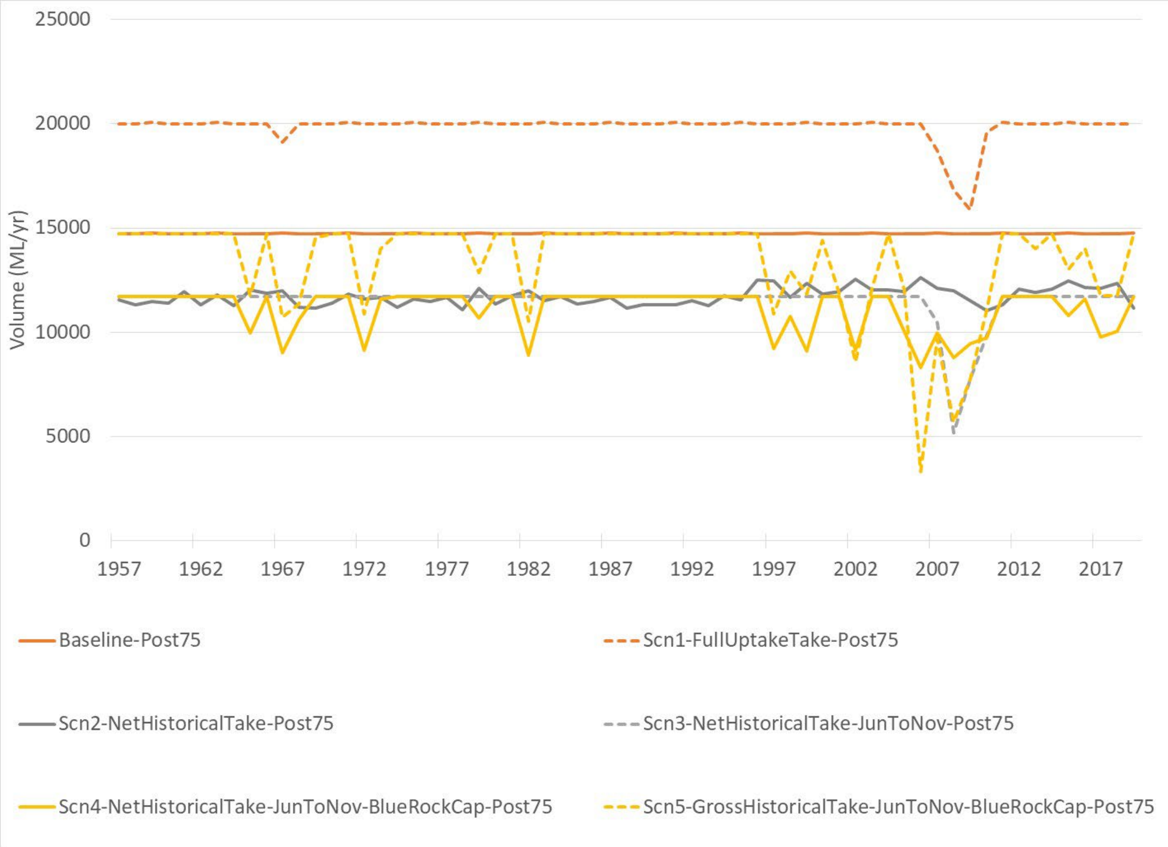


Figure 21 Annual supply for mine rehabilitation from Loy Yang B bulk entitlement

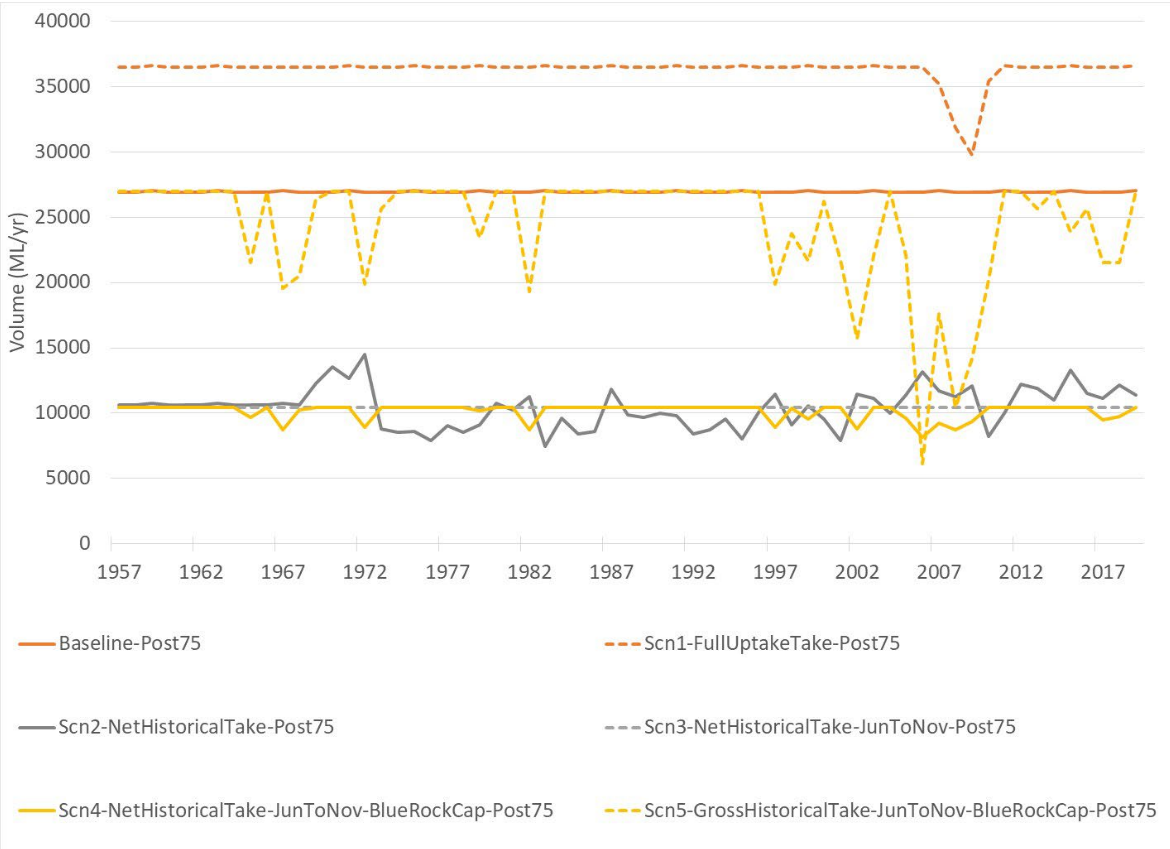


Figure 22 Annual supply for mine rehabilitation from Yallourn bulk entitlement

Appendix C2: Sensitivity test on Latrobe Reserve demand (Scenario 6 results)

As an addendum to this modelling, a further sensitivity was undertaken on the baseline and Scenario 5 with the modelled constant demand on the Latrobe Reserve (which is designed to minimise incidental internal spills in Blue Rock Reservoir to other entitlement holders) set to zero. The results of this scenario (#6) are provided below.

The Latrobe Reserve has two components to its demand for the baselines and Scenarios 1-5 in this report. These are:

1. Demand created by entitlement holders accessing the Latrobe Reserve when they face a water shortage (consistent with stated purpose of Latrobe Reserve bulk entitlement); and
2. A demand that is designed to minimise incidental internal spills from the Latrobe Reserve benefitting other Blue Rock Reservoir entitlement holders. Conceptually, this demand recognises that the internal spills from the Latrobe Reserve are an incidental benefit that may cease, such as following any reallocation of the Latrobe Reserve in response to the 2028 review and continuing reduction in requirements for very high security of water supply for coal-fired power generation.

To test the effect of this demand (for minimising incidental internal spills) on supply system behaviour, this demand was set to zero for one climate condition under the baseline, and for all modelled climate conditions for Scenario 5 (gross historical take with conditions on seasonal demand, unregulated flow harvesting, and releases from Blue Rock Reservoir for mine rehabilitation).

The average annual water balance in Table 42 shows the effect of this demand on the Latrobe Reserve for the baseline under post-1975 climate conditions. When this demand is reduced by 11.9 GL/yr to zero, Latrobe River outflows increase by the same amount, with negligible changes to average annual supply to other water users. Under the mine site rehabilitation Scenario 5 (with conditions on take and releases from Blue Rock Reservoir), reducing this component of the Latrobe Reserve demand by 11.9 GL/yr to zero only results in an increase in outflow from the Latrobe River of 9.8 GL/yr, with the power generator entitlements able to capture the difference through increased internal spills to their shares of storage, alongside a minor increase in supply to regulated private diverters along the Latrobe River for the same reason.

Internal spills from the Latrobe Reserve provide an increased supply for mine rehabilitation of 1-3 GL/yr on average across the different climate scenarios, with that benefit being at the higher end of this range under climate projections that are drier on average than the post-1975 climate baseline (Table 43). This is because the power generator shares of storage are drawn down more often under the drier climate projections, and hence are more readily able to receive any internal spills from the Latrobe Reserve.

Changes in irrigation supply reliability shows that when the additional demand on the Latrobe Reserve is removed, the percentage of years when more than 1% of the capacity of Blue Rock Reservoir is accessed by Southern Rural Water (Table 41):

- does not change under the post-1975 baseline (when irrigation reliability is already very high)
- increases by up to an additional 6% of years for Scenario 5 (gross historical take with conditions on take and Blue Rock Reservoir releases) under projected drier climate change scenarios.

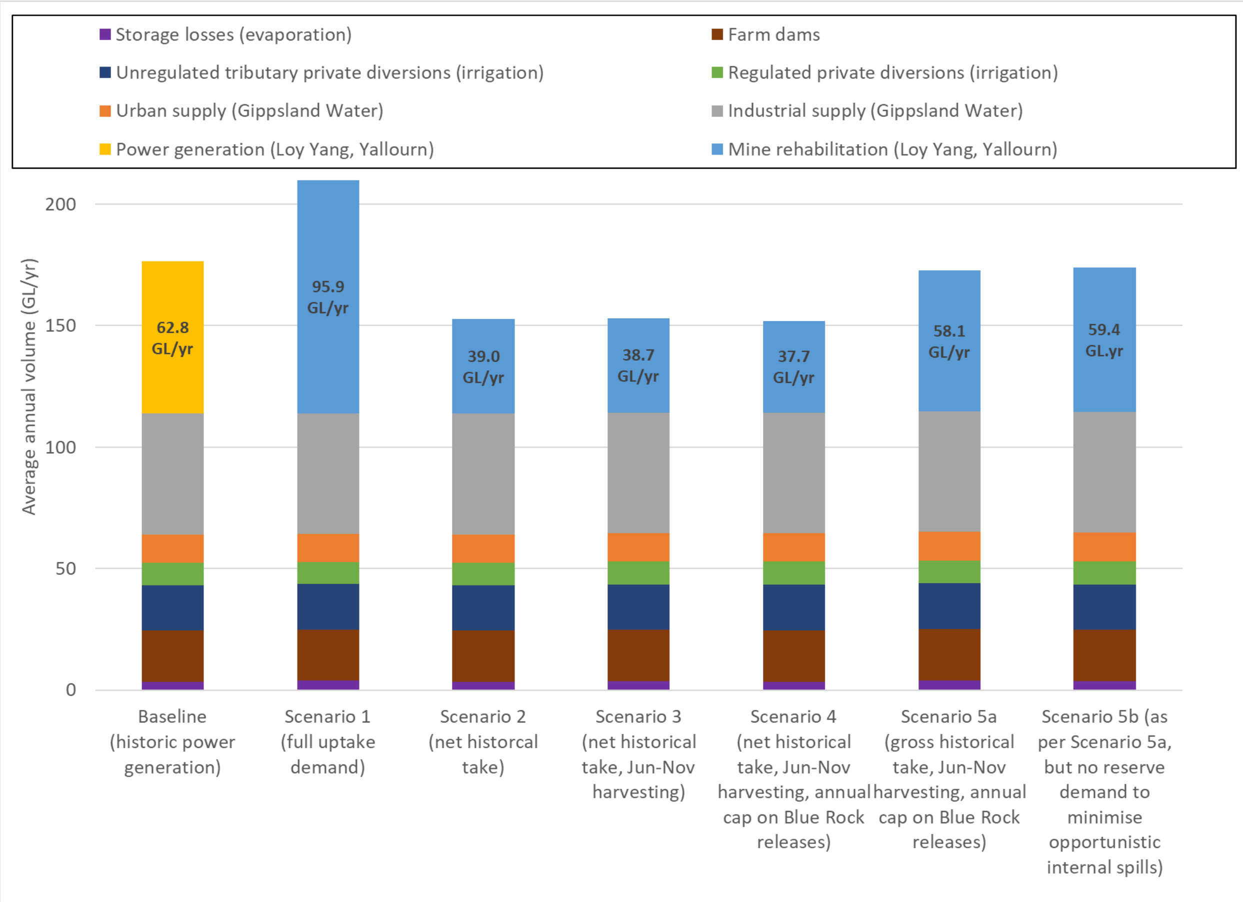
When scenario 6 is compared to a hypothetical equivalent baseline without the notional Latrobe Reserve demand, rural private diverters supplied from SRW's Latrobe River bulk entitlement would need to access water from the Latrobe Reserve in 8% more years, which is similar to the comparison between the baseline and scenario 5 (gross historical take with conditions and notional Latrobe Reserve demand in place). This demonstrates that the impacts on supply reliability to rural private diverters is not sensitive to the change in the notional Latrobe Reserve demand.

External spills from Blue Rock Reservoir to the Tanjil River increase when the demand on the Latrobe Reserve is reduced. This is the mechanism by which outflows from the Latrobe River increase when that Latrobe Reserve demand is reduced. Under the baseline under post-1975 climate conditions, the annual frequency of spills increases from 84% to 89% of years, with the average annual spill volume increasing from 49 GL/yr to 60 GL/yr. From Scenario 5 to Scenario 6 under post-1975 climate conditions, the annual frequency of spills increases from

49% to 59% of years, with the average annual spill volume increasing from 33 GL/yr to 41 GL/yr. External spills only occur when all shares of Blue Rock Reservoir are full, and internal spills are no longer possible.

The resulting changes in performance are shown in Appendix B1. There are no significant differences between Scenario 6 and Scenario 5 in the Latrobe River and estuary. In the Tanjil River, performance for larger flows – Winter/Spring freshes, Bankfull and Overbank flows are similar to that under the baseline, whereas Scenario 5 sees a drop in performance. This reflects the increase in frequency and volume of spills described above.

Compared to a hypothetical baseline without the notional Latrobe Reserve demand, these conditions may increase the risk to environmental and Traditional owner values in the Tanjil River under the post-1975 historic climate reference period. Scenario 6 does not change the risk to environmental values in the Latrobe River and may decrease risks to environmental and Traditional Owner values in the estuary relative to the hypothetical baseline without the notional Latrobe Reserve demand.



Notes:
The available water includes volumes intercepted by catchment farm dams that do not reach the waterways (refer “Farm dams”), and exclude Thomson River.
Regulated private diversions (irrigation) represent the sum of take under Southern Rural Water’s bulk entitlement and assumed take from the Latrobe Reserve to make up shortfalls. It includes some off-quota deliveries (~346 ML/year or ~4% of irrigator supply on average) that are triggered by regulated environmental entitlement deliveries from Blue Rock Reservoir.

Figure 23. *Distribution of available water for consumptive users under baseline and mine rehabilitation scenarios over the post-1975 historic climate reference period.*

Table 40. Annual Supply for Mine Rehabilitation(Note that Scenario 5 and 6 are at a different level of take from Scenarios 2,3,4)

Scenario	Bulk Entitlement	Maximum Annual Supply (GL/year)	Minimum Annual Supply (GL/year)	Annual Reliability of Supply (% of years with supply at historical net take)	Minimum no. of days of supply in driest year (from all sources)
Scenario 5: gross historical take, with all conditions	Loy Yang A	21.1	15.5	75%	145
	Loy Yang B	14.7	3.3	59%	131
	Yallourn	27.0	6.1	59%	131
	Total	62.8	26.2	59%	Not assessed
Scenario 6: As per Scenario 5, but no notional demand on Latrobe Reserve	Loy Yang A	21.1	16.7	76%	145
	Loy Yang B	14.7	9.2	62%	115
	Yallourn	27.0	16.9	62%	115
	Total	62.8	43.7	62%	Not assessed

**In the table above, the annual reliability of supply for the sum of all power generators was the same as the lowest annual reliability of the individual power generators. This is because when supply from any individual entitlement is less than its demand, the total supply from all entitlements will always be less than the total demand from those entitlements.

Table 41 Reliability of Supply Performance Indicators, Jul 1957 to June 2020, with (Scenario 5) and without (Scenario 6) Latrobe Reserve demand to minimise incidental internal spills

Scenario	Climate scenario	Irrigation Annual Reliability (% of years when Latrobe Reserve is not accessed)	Irrigation Annual Reliability (% of years when <1% of Blue Rock capacity is accessed from the Latrobe Reserve)
Baseline (historic power generation)	Post-1975	89%	98%
Baseline with no demand to minimise incidental internal spills		94%	98%
Scenario 5: Gross historical take, Jun-Nov harvesting, annual cap on Blue Rock releases		79%	89%
Scenario 6: As per Scenario 5 but no demand to minimise incidental internal spills		87%	90%
Scenario 5: Gross historical take, Jun-Nov harvesting, annual cap on Blue Rock releases	2065 low climate change	79%	89%
Scenario 6: As per Scenario 5 but no demand to minimise incidental internal spills		87%	90%
Scenario 5: Gross historical take, Jun-Nov harvesting, annual cap on Blue Rock releases	2065 medium climate change	54%	75%
Scenario 6: As per Scenario 5 but no demand to minimise incidental internal spills		60%	79%
Scenario 5: Gross historical take, Jun-Nov harvesting, annual cap on Blue Rock releases	2065 high climate change	13%	32%
Scenario 6: As per Scenario 5 but no demand to minimise incidental internal spills		16%	38%

Table 42 Average Annual Water Balance, Jul 1957 to June 2020 (GL/year) for Baseline and Scenarios under post-1975 climate conditions with and without Latrobe Reserve demand to minimise incidental internal spills

Water Balance Category	Water Balance Item	Baseline		Mine Site Rehabilitation Scenarios	
		Baseline (historic power generation)	Baseline with no reserve demand to minimise incidental internal spills	Scenario 5: Gross historical take, Jun-Nov harvesting, annual cap on Blue Rock releases	Scenario 6: As per Scenario 5 but no reserve demand to minimise incidental internal spills
Inflows					
	Catchment inflows	837.3	837.3	837.3	837.3
	Return flows and recycled water	44.4	44.4	20.6	20.6
Total inflows		**881.7**	**881.7**	**857.9**	**857.9**
Diversions					
	Net farm dam supply	21.1	21.1	21.1	21.1
	Urban supply	11.7	11.7	11.7	11.7
	Industrial/mine supply under GW bulk entitlement	49.6	49.7	49.6	49.7
	Power generation supply under generator bulk entitlements	62.8	62.8	0.0	0.0
	Private diversions under SRW's Latrobe River bulk entitlement[#]	9.3	9.3	9.5	9.6
	Other rural private diversions	18.7	18.7	18.7	18.7
	Notional demand on 3/4 Bench	14.4	14.4	14.4	14.4
	Notional demand on Latrobe Reserve	11.9	0.0	11.7	0.0
Total diversions excluding water for mine site rehabilitation		**199.5**	**187.7**	**136.8**	**125.2**
Water for mine site rehabilitation		**0.0**	**0.0**	**58.1**	**59.4**
Losses (net evaporation from reservoirs)		3.6	3.6	3.4	3.5
Outflows					
	Latrobe River environmental entitlement	15.9	**16.0**	15.8	15.9
	Latrobe River GLaWAC	0.0	**0.0**	0.0	0.0
	Latrobe River unregulated and min. passing flows	662.4	**674.1**	644.4	654.1
	Total outflows (Latrobe River upstream of Thomson River)	**678.3**	**690.2**	**660.2**	**670.0**
Increase in storage		0.2	**0.1**	-0.7	-0.2
Mass Balance Error		0.0	0.0	0.0	0.0
Mass Balance Error (% of inflows)		0.0%	0.0%	0.0%	0.0%

*Inflows include volumes intercepted by catchment farm dams that do not reach the waterways (refer line item "Farm dam impacts"), and exclude Thomson River.

^These represent the sum of take under Southern Rural Water's bulk entitlement and assumed take from the Latrobe Reserve to make up shortfalls.

[#]Includes some off-quota deliveries (~346 ML/year or ~4% of irrigator supply on average) that are triggered by regulated environmental entitlement deliveries from Blue Rock Reservoir

Table 43 Average Annual Water Balance, Jul 1957 to June 2020 (GL/year) under projected climate change with (Scenario 5) and without (Scenario 6) Latrobe Reserve demand to minimise incidental internal spills

Water Balance Category	Water Balance Item	2065 low climate change		2065 medium climate change		2065 high climate change	
		Scenario 5	Scenario 6	Scenario 5	Scenario 6	Scenario 5	Scenario 6
Inflows							
	Catchment inflows	838.1	838.1	700.8	700.8	489.8	489.8
	Return flows and recycled water	20.6	20.6	20.6	20.6	20.6	20.6
Total inflows		**858.7**	**858.7**	**721.4**	**721.4**	**510.4**	**510.4**
Diversions							
	Net farm dam supply	21.1	21.1	21.1	21.1	20.7	20.7
	Urban supply	11.7	11.7	11.7	11.7	10.9	10.9
	Industrial/mine supply under GW bulk entitlement	49.6	49.7	48.6	48.8	43.0	43.4
	Power generation supply under generator bulk entitlements	0.0	0.0	0.0	0.0	0.0	0.0
	Private diversions under SRW's Latrobe River bulk entitlement[#]	9.5	9.6	8.8	8.9	8.0	8.0
	Other rural private diversions	18.7	18.7	18.4	18.4	17.5	17.5
	Notional demand on 3/4 Bench	14.4	14.4	14.4	14.4	14.4	14.4
	Notional demand on Latrobe Reserve	11.7	0.0	10.4	0.0	5.0	0.0
Total diversions excluding water for mine site rehabilitation		136.8	125.2	133.4	123.3	119.6	115.0
Water for mine site rehabilitation		**58.1**	**59.3**	**50.6**	**53.0**	**29.5**	**32.4**
Losses (net evaporation from reservoirs)		3.8	4.0	4.5	4.7	4.8	5.1
Outflows							
	Latrobe River environmental entitlement	15.7	15.9	14.9	15.2	12.6	12.8
	Latrobe River GLaWAC	0.0	0.0	0.0	0.0	0.0	0.0
	Latrobe River unregulated and min. passing flows	644.9	654.5	519.1	526.1	345.7	346.8
	Total outflows (Latrobe River upstream of Thomson River)	**660.7**	**670.4**	**534.0**	**541.3**	**358.3**	**359.5**
Increase in storage		-0.7	-0.2	-1.2	-0.9	-1.7	-1.6
Mass Balance Error		0.0	0.0	0.0	0.0	0.0	0.0
Mass Balance Error (% of inflows)		0.0%	0.0%	0.0%	0.0%	0.0%	0.0%

*Inflows include volumes intercepted by catchment farm dams that do not reach the waterways (refer line item "Farm dam impacts"), and exclude Thomson River.
^These represent the sum of take under Southern Rural Water's bulk entitlement and assumed take from the Latrobe Reserve to make up shortfalls.
[#]Includes some off-quota deliveries (~346 ML/year or ~4% of irrigator supply on average) that are triggered by regulated environmental entitlement deliveries from Blue Rock Reservoir