GBCCL Source Model

Modelling for Constraints Measures Program

Surface Water Assessment and Modelling
Water Resource Strategy
Final, April 2024

Goulburn River at Shepparton

Energy, Environment and Climate Action

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Acknowledgment

We acknowledge and respect Victorian Traditional Owners as the original custodians of Victoria's land and waters, their unique ability to care for Country and deep spiritual connection to it. We honour Elders past and present whose knowledge and wisdom has ensured the continuation of culture and traditional practices.

We are committed to genuinely partner, and meaningfully engage, with Victoria's Traditional Owners and Aboriginal communities to support the protection of Country, the maintenance of spiritual and cultural practices and their broader aspirations in the 21st century and beyond.

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1 Introduction

This report outlines developments made to the Source model of the Goulburn, Broken, Campaspe, Coliban and Loddon (GBCCL) systems in April to October 2022, and scenario modelling undertaken for Stage 1A of the Constraints Measures Program (CMP). There are a number of investigations being carried out to support the CMP. The Source hydrological modelling simulates flow characteristics under current and various relaxed constraint scenarios with a given set of environmental demand assumptions. This report presents the outcomes of this modelling, which have been used to inform the Murray constraints modelling (MDBA, 2022), hydrological synthesis report (HARC, 2022) and the Stage 1A Feasibility Study Report for the Victorian Constraints Measures Program (Sequana, 2022).

Source is the new national hydrological modelling platform, which simulates all aspects of water supply systems. In Victoria, it replaces the REALM software that has been used for more than 20 years. Victoria's REALM to Source transition strategy commenced in 2018, and Victorian valley models are now being progressively developed using the Source platform. More information can be found on the Victorian surface water modelling website (https://www.water.vic.gov.au/water-reporting/surface-water-modelling), or eWater Source website (https://ewater.org.au/products/ewater-source/).

The Source model offers the advantage of a daily timestep and is therefore more appropriate for modelling daily environmental water requirements and constraints than the monthly timestep REALM Goulburn Simulation Model (GSM).

Using the model to mimic reality is challenging, as conditions and system operations are continuously evolving, and it takes time for new information and recorded data to become available. Continuous improvement and updates to the model are therefore critical and ongoing tasks, and models should be selected using the best available information and assessed as fit for purpose. Note that the model has been evaluated as fit for purpose for use in this project and should be reviewed before use in any other application.

2 GBCCL Model Overview

2.1 Foundational Model

Development of a daily foundational model of the GBCCL began in 2018, with an independent review of the model undertaken in 2019/20. The foundational model reflects conditions at 30 June 2009. It includes the following features:

- Daily model running from 1891 to 2020 with flow routing, travel times and losses along the river systems.
- Key management and operating rules to generally represent a level of development based on conditions in 2009, including water infrastructure and entitlements.
- Annual resource assessments for Goulburn, Broken, Coliban, Campaspe and Loddon irrigation supply systems, with various water accounting arrangements for different water users.

2.2 Current Conditions Model

The GBCCL current conditions model generally reflects conditions at 30 June 2019[1]. It was developed using the foundational model as a starting point, with the following changes:

- Key management and operating rules to generally represent a level of development based on conditions in 2019, including water infrastructure and entitlements.
- Introduction of the reserve policies for the Goulburn system, carryover and Spillable Water Accounts (SWAs) rules.
- Application of environmental flow demands along the river systems to deliver environmental water holder entitlements created from the water savings and purchase.
- Preliminary (simplified) modelling of Goulburn to Murray allocation trade.

The following sections detail some of the assumptions used in the model for the purposes of CMP modelling.

2.2.1 Constraint Assumptions

Table 1 below summarises the constraint assumptions in the GBCCL current conditions model, which were confirmed with the CMP project team and are based on consultation with Goulburn-Murray Water as the responsible river operator.

Table 1: Summary of Goulburn Constraints in Current Conditions Model

Location	Modelled Constraint (ML/d)
Eildon release	9,500
Molesworth	10,000
Murchison	9,500
Shepparton	9,500

2.2.2 Goulburn IVT Assumptions

A new Goulburn to Murray trade rule came into effect on 1 July 2022, which aims to align trade opportunity with what can sustainably be delivered in the lower Goulburn River (i.e. keeping flows lower and more variable over summer and autumn). Details of the trade rule can be found in this fact sheet on the Victorian

[1] Whilst the current conditions model generally reflects conditions at 30 June 2019, some recent system changes have been included for the purpose of constraints modelling. These changes reflect the current trade rule for the lower Goulburn (refer Section 2.2.2) and updated environmental demand assumptions (refer Section 3).

Water Register website: Goulburn to Murray Trade Review Fact Sheet 1 - long-term trade rule (waterregister.vic.gov.au).

A preliminary representation of the trade rule has been included in the GBCCL current conditions model for constraints modelling. This representation was discussed and agreed with the DELWP Water Entitlements and Markets (WEM) team in June 2022. It is important to note that the assumptions used are:

- an approximation of how much water from the Goulburn IVT account is delivered down the lower Goulburn,
- still preliminary and will need to continue to be refined and improved in future,
- not to be used as an indicator of all aspects of the IVT account or the IVT balance, as they:
    - don’t reflect how water is delivered down the Campaspe and Lower Broken Creek,
    - don’t reflect trade behaviour and other factors that are likely to have significant impact on the actual IVT balance.

Permanent Trade

Table 2 below shows the permanently traded entitlements and Snowy entitlement from the Goulburn system as at 30 June 2019. These are the permanent trade volumes assumed in the GBCCL current conditions model.

Table 2: Summary of Goulburn to Murray permanent trade at 30 June 2019

IVT Account		HRWS Entitlement (ML)	LRWS Entitlement (ML)
Permanent trade	Legacy exchange rate trade	99,488	
	Tagged trade	43,092	15,931
Snowy entitlement		38,573	26,008
Total permanent trade and Snowy entitlement		**181,453**	**41,939**

The modelled trade rule assumes that Goulburn seasonal determinations for high-reliability entitlements will get to 100%, and that the high-reliability entitlements in Table 2 will need to be fully delivered.

Allocation Trade

On top of the permanent trade commitments, the following allocation (seasonal) trade opportunities are made available in the model:

- On 1 July, an opening trade opportunity of 85 GL;
- On 15 October, an additional new trade opportunity of 11 GL; and
- On 15 December, an additional new trade opportunity of 11 GL.

Total Trade

The above assumptions limit the total allocation and high reliability tagged trade volume to 150 GL/yr, and the total high reliability volume (including legacy trade and Snowy entitlement) to around 290 GL/yr.

Modelled ordering and delivery of IVT is subject to the available water in the IVT account, Goulburn River operating rules, River Murray conditions and the constraints set out in the model. The ordering of IVT is determined as follows:

- If the IVT account balance is less than 290 GL, the monthly delivery pattern shown in Table 3 is applied to the available water in the Goulburn IVT account for that month.

- If the IVT account balance is 290 GL or more, the maximum order for each month is shown in Table 4. Note that the maximums for November to March reflect the expected maximum IVT deliveries, whereas the maximums for April to October reflect the maximum total deliveries specified in the operating rules for the lower Goulburn River, June 2021 (available on the Victorian Water Register website).

Table 3: Monthly IVT delivery pattern applied to the available water in the Goulburn IVT account

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
13.1%	13.4%	16.2%	8.6%	1.7%	1.7%	0%	0%	5.9%	12.1%	11.4%	15.9%

Table 4: Maximum monthly IVT order if IVT balance is 290 GL or more (GL)

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
38	39	47	25	34	33	40	40	39	40	33	47

The daily pattern is currently modelled as uniform within each month, however there is scope to improve this by adding some within-month variability (e.g. pulses for December to March).

Other factors affecting modelled IVT orders and deliveries are as follows:

- Existing channel capacity constraints (e.g. current constraints of 9,500 ML/d at Murchison and Shepparton);
- Goulburn summer low flow constraint (total monthly flow at Murchison cannot exceed the volumes in Table 4 for December to March);
- No IVT orders when the Murray upstream of the Goulburn confluence is in unregulated conditions (based on output “OffAllocation Index at Ovens ds” from the Source Murray Model).

The model does not assume any change to trade opportunities as a result of relaxing constraints, however relaxed constraints do enable some additional Goulburn IVT deliveries to occur during the April to November months (i.e. outside of the restricted summer low flow period). Note that the daily averages of the maximum monthly IVT orders in Table 4 are well within current constraints.

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3 Environmental Demands

3.1 Goulburn Environmental Water Portfolio

Table 5 below summarises the environmental entitlements in the Goulburn system at 30 June 2019, which have been included in the GBCCL current conditions model[2]. Note that the Silver and Wallaby Creeks environmental entitlement has not been included, as it is outside of the model extent. For details of the Snowy Environmental Reserve, refer to Section 2.2.2.

Table 5: Goulburn Environmental Entitlements as at June 2019

Entitlement		High Reliability (ML)	Low Reliability (ML)
Goulburn River Environmental Entitlement 2010	For use in Goulburn	25,121	5,792
	For use in Loddon Only accessible during irrigation season	1,434	
CEWH water shares		317,453	42,467
The Living Murray (TLM)	Extended use Valley Cap applies		141,200
	Extended use	19,164	
		26,020	15,780

The use of each of these entitlements to supply demands in the Goulburn and Murray is dependent upon the assumed account prioritisation specified in the model.

3.2 Goulburn Environmental Demands

3.2.1 Water Availability Scenarios

The following water availability scenarios are used in the modelling of Goulburn environmental demands:

- Drought
- Dry
- Below Average
- Average
- Wet

These reflect the planning scenarios used by the VEWH in the Goulburn system. In practice, determining which scenario to operate to involves consideration of many variables, such as climate forecasts and outlooks, account balances, and antecedent conditions. In the model, a simpler approach has been taken, by using the available water in the environmental accounts at the beginning of August each year (or beginning of July for winter fresh), as shown in Table 6. This follows the method used by the University of Melbourne in their modelling of Goulburn environmental water demands for the CMP.

[2] Environmental entitlements have been created from water recovery, which includes water savings and purchase of entitlements. Therefore, the model now represents modernised system loss behaviour plus transfer of entitlements from consumptive users to the environment.

Table 6: Definition of water availability scenarios within the GBCCL

Water availability scenario	Volume of water available in environmental accounts at beginning of August (or beginning of July for winter fresh)
Drought	< 200,000 ML
Dry	200,000 to 299,999 ML
Below average	300,000 to 429,999 ML
Average	430,000 to 552,000 ML
Wet	> 552,000 ML

The current scenario then informs various model parameters, such as the target, duration and importance of individual environmental actions.

3.2.2 Goulburn Environmental Actions

Goulburn environmental actions in the GBCCL have been targeted using an Environmental Flow Node (EFN) located at Shepparton (Reach 4). Orders from the EFN are passed through Goulburn Weir to Lake Eildon. There are six routing links between Lake Eildon and the Reach 4 EFN: four upstream of Goulburn Weir, and two downstream. The rounded average travel time between Eildon and the Reach 4 EFN is four days.

Lower Goulburn events are generally targeted at both Reach 4 and Reach 5 (McCoys Bridge), however the routing links and travel times between the reaches make it difficult to enable ordering for a single event at both locations. Based on advice from environmental water managers, the model has been set up to meet targets in Reach 4, with the assumption that the targets will also be met further downstream at Reach 5.

Table 7 below summarises the Goulburn environmental actions modelled in Reach 4. This information is based on the 2020 updated Goulburn flow recommendations, as used by the University of Melbourne in their modelling of Goulburn environmental water demands for the CMP, with some further refinements made in consultation with the Victorian Environmental Water Holder (VEWH) and the Goulburn Broken Catchment Management Authority (GBCMA) for Source modelling purposes (e.g. spell start trigger, success criteria and forced spell delivery assumptions).

Note that while the model requires a set of rules and triggers for modelling environmental demands, real world environmental water deliveries are much more flexible and decisions are based on a range of considerations that cannot always be captured in the model for various reasons, including modelling software and data limitations.

Table 7: Goulburn environmental actions modelled in Goulburn River Reach 4 EFN

Action Type	Season	Trigger Flow to Start Spell (ML/d)	Target Flow (ML/d)	Duration (d)	Rise and Fall	Success Criteria	Notes/Assumptions
Winter/early spring fresh (overbank if constraints allow)	1 Jul to 31 Oct	Unreg inflows >40% of target	Wet/Av: 30,000 Below Average: 20,000 Dry/Drought: 15,000	5	Rise: 6 days, 20% Fall: 20 days, 10%	80% target 40% duration	Target may be limited by modelled constraint. If spell start threshold not met, force delivery at end of season each year.
Late spring fresh	1 Nov to 31 Dec	Unreg inflows >30% of target	7,500 ML/d	2	Rise: 4 days, 20% Fall: 9 days, 10%	80% target 50% duration	Not targeted under Drought scenario. Only allows orders in November due to summer flow restrictions.
Autumn fresh	1 Mar to 30 Apr	Unreg inflows >30% of target	5,700 ML/d Below Average: 4,275 ML/d	2	Rise: 3 days, 20% Fall: 6 days, 10%	80% target 50% duration	Partial (75%) delivery under Below Average scenario. Not targeted under Drought scenario. If spell start threshold not met, force delivery at end of season each year. Only allows orders in April due to summer flow restrictions.
Year-round baseflow	1 Jul to 30 Jun	n/a	750 ML/d	n/a	n/a	100% target 100% duration	
Winter/spring variable baseflow	1 Jul to 31 Oct	n/a	1,250 ML/d	n/a	n/a	100% target 100% duration	

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3.3 Murray Environmental Orders

Environmental orders for the Murray from the Goulburn are modelled as a spell-based action in the Goulburn Reach 4 EFN. The Murray orders are derived by the MDBA using the Source Murray Model and outputs from an initial GBCCL run with Goulburn environmental demands only. A second iteration is then run using the GBCCL, with the Murray orders input as a target flow timeseries, which is based on flow at Shepparton from the initial run with the Murray orders added on top (with offset for travel time). The following conditions are applied when deriving and implementing Murray orders to ensure that the existing Goulburn flows and environmental deliveries are not impacted by the additional orders:

- Murray orders are only enabled from 1 May to 31 October. This avoids issues with delivery restrictions over the November to April period.
- Murray orders are only enabled when water available in Goulburn environmental accounts is above 450 GL. This is to avoid Murray orders affecting Goulburn environmental flow targets, which vary between the below average (<430 GL) and average (≥430 GL) water availability scenarios.
- Target flow (i.e. first iteration flow plus Murray order) is limited to modelled constraints.
- Target flow is set to zero if there are no Murray orders on that day. This prevents the model from making advance orders to meet future flow rates when there are no Murray demands.

3.4 Environmental Demand Prioritisation

Table 8 below shows the relative priority assigned to the environmental actions under each water availability scenario. This information was based on that used by the University of Melbourne in their modelling of Goulburn environmental water demands for the CMP.

Table 8: Relative priority of Goulburn environmental actions under each water availability scenario

Action	Relative priority under each water availability scenario				
	Drought	Dry	Below Average	Average	Wet
Year-round baseflow	1	1	1	1	1
Winter/early spring fresh (overbank if constraints allow)	2	2	2	2	2
Winter/spring variable baseflow	3	3	3	4	5
Late spring fresh	n/a*	4	5	3	4
Autumn fresh	n/a*	5	4	5	3
Murray orders†	4	6	6	6	6

**Not targeted under Drought scenario*

†Murray orders are determined following Goulburn environmental deliveries (refer Section 3.3)

3.5 Modelled Environmental Deliveries

Figure 1 and Figure 2 below show comparisons of the modelled and recorded flows at McCoys Bridge in 2018/19 and 2019/20 respectively.

The 2018/19 year does not match as well as the 2019/20 year for several reasons, including the high recorded summer-autumn deliveries, which were restricted by the lower Goulburn trade rule in the model, and the recorded winter fresh, which started outside of the modelled winter fresh period.

The 2019/20 modelled winter fresh matches quite well with the recorded fresh, however there was a second recorded event in September/October that is not reflected by the modelled environmental demand assumptions.

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These comparisons show that the model will not always match past practice, as it applies a single set of rules for every year, whereas past operations have changed and evolved over time.

Future improvements to the modelling of Goulburn environmental demands include improved flow forecasting and more efficient use of environmental water, within-month flow variation over summer, and inclusion of recession management and higher baseflows/natural passing flows from the mid to lower Goulburn.

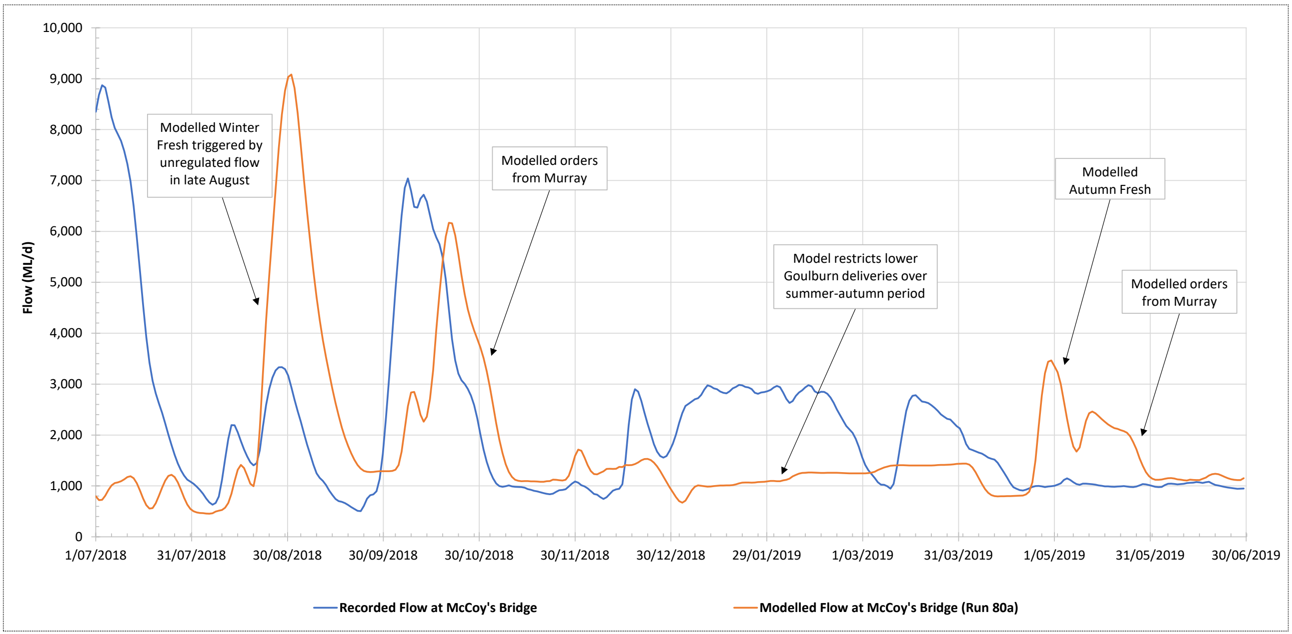

Figure 1: Comparison of Modelled vs Actual Environmental Deliveries in the Goulburn in 2018/19

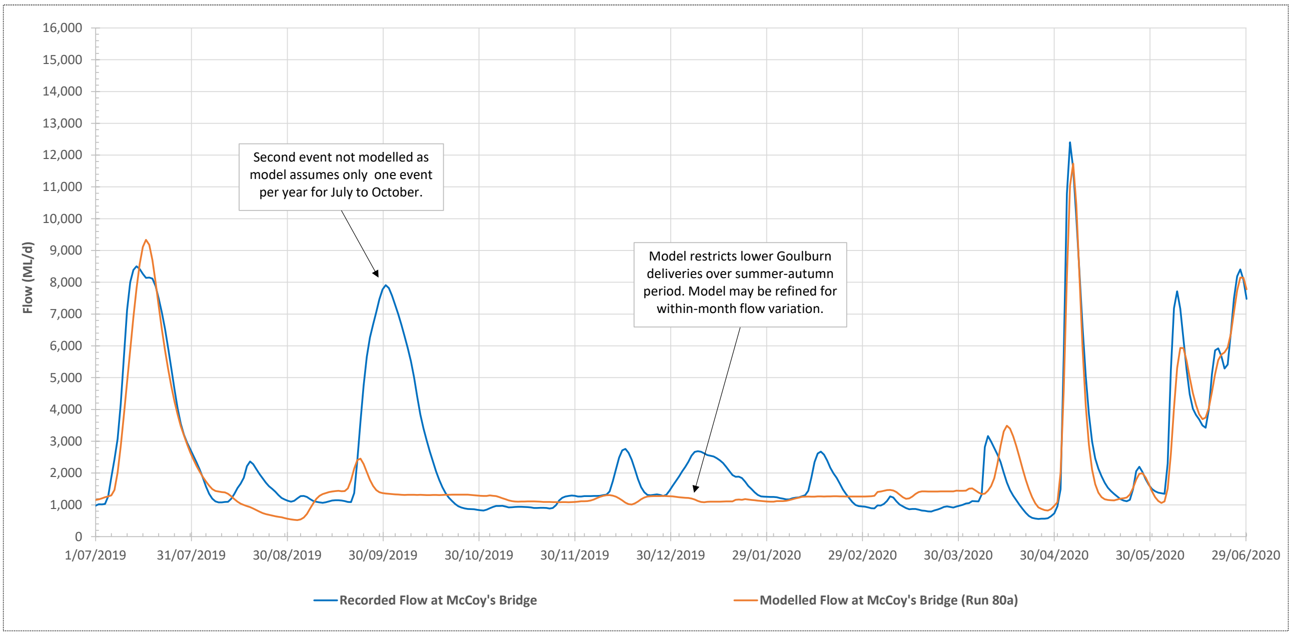

Figure 2: Comparison of Modelled vs Actual Environmental Deliveries in the Goulburn in 2019/20

4 Scenario Modelling

4.1 Relaxed Constraint Scenarios

Table 9 summarises the current and four relaxed constraint scenarios assumed in the modelling.

Table 9: Summary of Goulburn Relaxed Constraint Scenarios

Location	Current Constraints (M10L9.5)	Relaxed Constraints Scenarios				
		Scenario 1 (M10L17)	Scenario 2 (M10L21)	Scenario 3 (M12L21)	Scenario 5 (M12L25)	Scenario 4 (M14L25)
Eildon release	9,500 ML/d	9,500 ML/d	9,500 ML/d	12,000 ML/d	12,000 ML/d	13,700 ML/d
Molesworth	10,000 ML/d	10,000 ML/d	10,000 ML/d	12,000 ML/d	12,000 ML/d	14,000 ML/d
Shepparton	9,500 ML/d	17,000 ML/d	21,000 ML/d	21,000 ML/d	25,000 ML/d	25,000 ML/d

Figure 3 below shows the differences in use of the Goulburn environmental water portfolio between the current and relaxed constraint scenarios. It also shows the difference in environmental use with and without environmental orders from the Murray. As lower Goulburn constraints are relaxed, more of the Goulburn environmental portfolio is able to be used to meet environmental requirements in the Goulburn, and Murray orders decrease (i.e. the difference between the dotted yellow line and solid yellow line decreases).

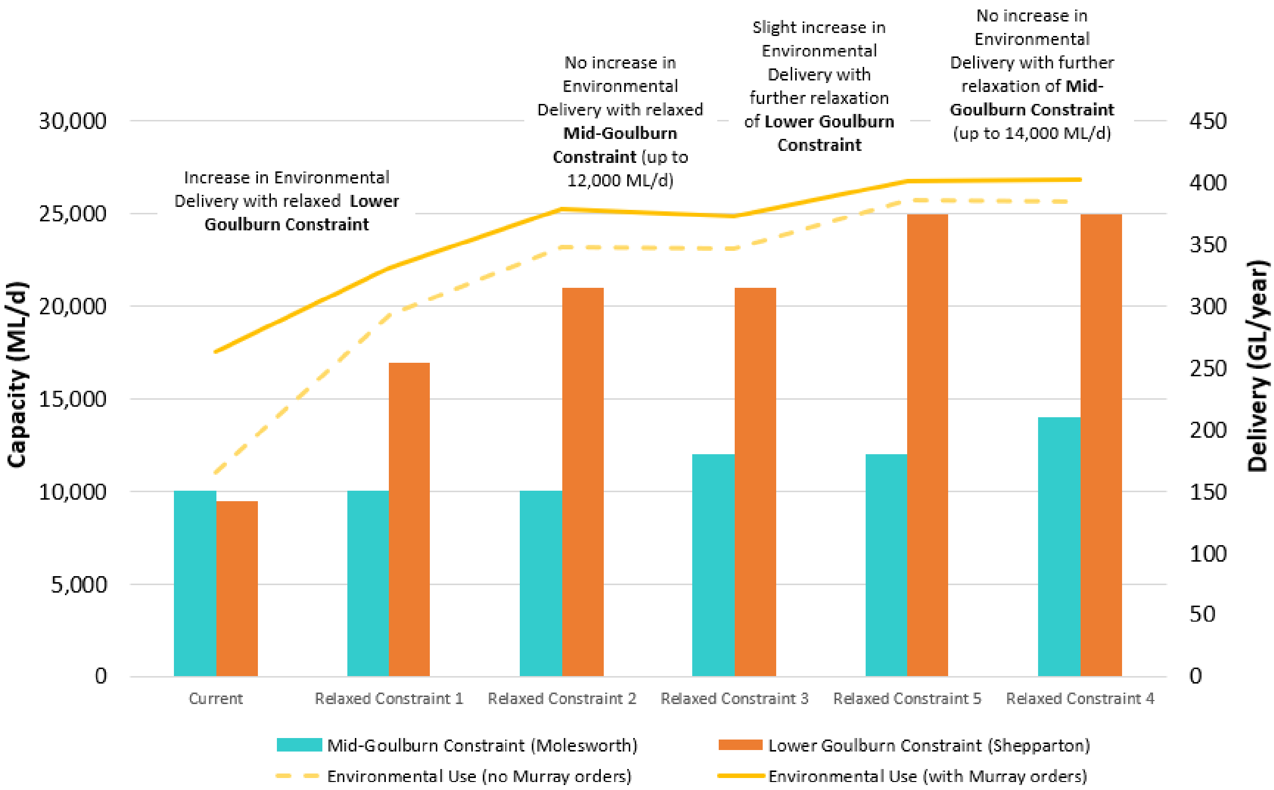

Figure 3: Use of Goulburn Environmental Water Portfolio under Current and Relaxed Constraint Scenarios

Table 10 below shows the utilisation rate (environmental use as a percentage of available water) for each scenario, with and without Murray orders. It is important to note that although modelled utilisation is used to make comparisons between scenarios, actual utilisation figures will vary significantly due to climate and water availability, environmental demand assumptions and real-world flexibility (rather than fixed model rules). The sensitivity of this variable to climate can be seen by comparing utilisation over the long-term

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historic period (1895-2020) with the drier period experienced over the last 20 years (2000-2020). Under current constraints and the modelled environmental demand, utilisation is 58% over the long-term period, compared to 78% over the drier period.

Under current constraints and the long-term historical climate sequence, environmental utilisation is limited by channel constraints, timing of water availability and how the environmental demand is ordered. As constraints are relaxed, a higher proportion of the environmental water is able to be used to directly target the environmental demands. Further refinements to the model (e.g. debiting of losses) may also increase the environmental water utilisation.

Table 10: Goulburn Environmental Utilisation Rates under Current and Relaxed Constraint Scenarios

Scenario	Environmental Utilisation (Goulburn demands only)	Environmental Utilisation (Goulburn and Murray demands)
Current (M10L9.5)	36%	58%
Scenario 1 (M10L17)	64%	72%
Scenario 2 (M10L21)	75%	81%
Scenario 3 (M12L21)	75%	81%
Scenario 5 (M12L25)	83%	87%
Scenario 4 (M14L25)	83%	87%

4.1.1 Relaxing the Lower Goulburn Constraint

Figure 4 below shows a comparison of average monthly environmental use between the current constraints and Relaxed Constraint Scenario 2, which has the lower Goulburn constraint relaxed to 21,000 ML/d.

By relaxing the lower Goulburn constraint, higher flows can be targeted for the winter/early spring fresh in July to October, resulting in a significant increase in utilisation of environmental water (see Table 10). The water used to meet these higher targets in the lower Goulburn may come from unregulated flow in the mid-Goulburn that is redirected downstream of Goulburn Weir, rather than being harvested to Waranga Basin. This can add up to around 7,000 ML/d towards the flow target (combined capacity of Cattanach and Stuart Murray Canals). When there is insufficient unregulated flow to meet the target, additional water may be released from Eildon, subject to capacity constraints in the mid-Goulburn.

Note that this increased use in winter-spring results in decreased water availability for the rest of the year, and therefore decreased use over April-June. The model configuration could be adjusted in future modelling, if these changes in use are considered important.

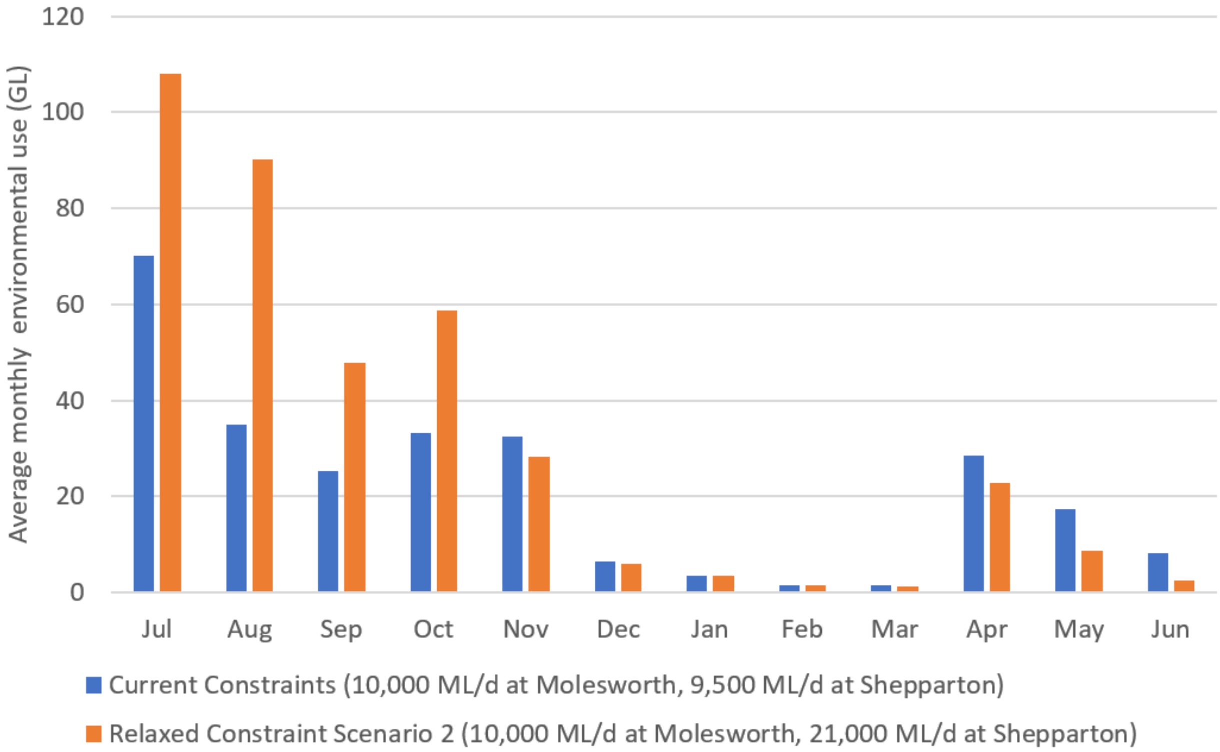

Figure 4: Average Monthly Environmental Use under Current and Relaxed Constraints (Scenario 2)

4.1.2 Relaxing the Mid-Goulburn Constraint

The utilisation figures in Table 10 show no difference between Scenario 2 with a mid-Goulburn constraint of 10,000 ML/d and Scenario 3 with a 12,000 ML/d constraint. What does differ is the efficiency of this water use – that is, how often the targeted flows meet the success criteria (refer Table 7). Table 11 shows the winter fresh targets for Relaxed Constraint Scenarios 2 and 3, and how often these are met successfully under each scenario. Note that "success" in this context is as evaluated by Source, and does not include unregulated events that meet the fresh targets outside of the periods expected by the model. This parameter is useful for illustrating the differences between scenarios, however for other purposes a more detailed assessment of success frequency may be required.

The ability to release up to 2,500 ML/d of additional flow from Eildon under Scenario 3 means that winter fresh targets are achieved more frequently.

Table 11: Winter Fresh Success Rates for Relaxed Constraint Scenarios 2 and 3

Winter Fresh Target[1]	Scenario 2 (M10L21)			Scenario 3 (M12L21)		
	Years Targeted	Years Successful	% Successful	Years Targeted	Years Successful	% Successful
15,000 ML/d for 5 days[2]	17	11	**65%**	19	14	**74%**
20,000 ML/d for 5 days[3]	27	11	**41%**	19	9	**47%**
21,000 ML/d for 5 days[4]	81	48	**59%**	87	57	**66%**
All targets	125	70	**56%**	125	80	**64%**

[1] Winter fresh success criteria: 80% of target, 40% of duration

[2] Winter fresh target under Dry and Drought water availability scenarios.

[3] Winter fresh target under Below Average water availability scenario.

[4] Winter fresh target under Average and Wet water availability scenarios is 30,000 ML/d, but target is limited to lower Goulburn constraint of 21,000 ML/d for Scenarios 2 and 3.

Figure 5 shows the change in the monthly pattern of use between Scenario 2 and Scenario 3. Although average annual use is similar for both scenarios, the water used in Scenario 3 is meeting winter flow targets (July-October) more frequently with less failed attempts. Under Scenario 3, more water is used in July, with

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the relaxed mid-Goulburn constraint allowing a successful winter fresh to be delivered earlier in the season. This reduces the number of years when a fresh delivery is attempted in August and September, and hence reduces average use in those months. In dry years, when there is insufficient unregulated flow to trigger an event, the model will try to force a delivery at the end of October. More water can be delivered as part of these forced events under Scenario 3, increasing average use in October.

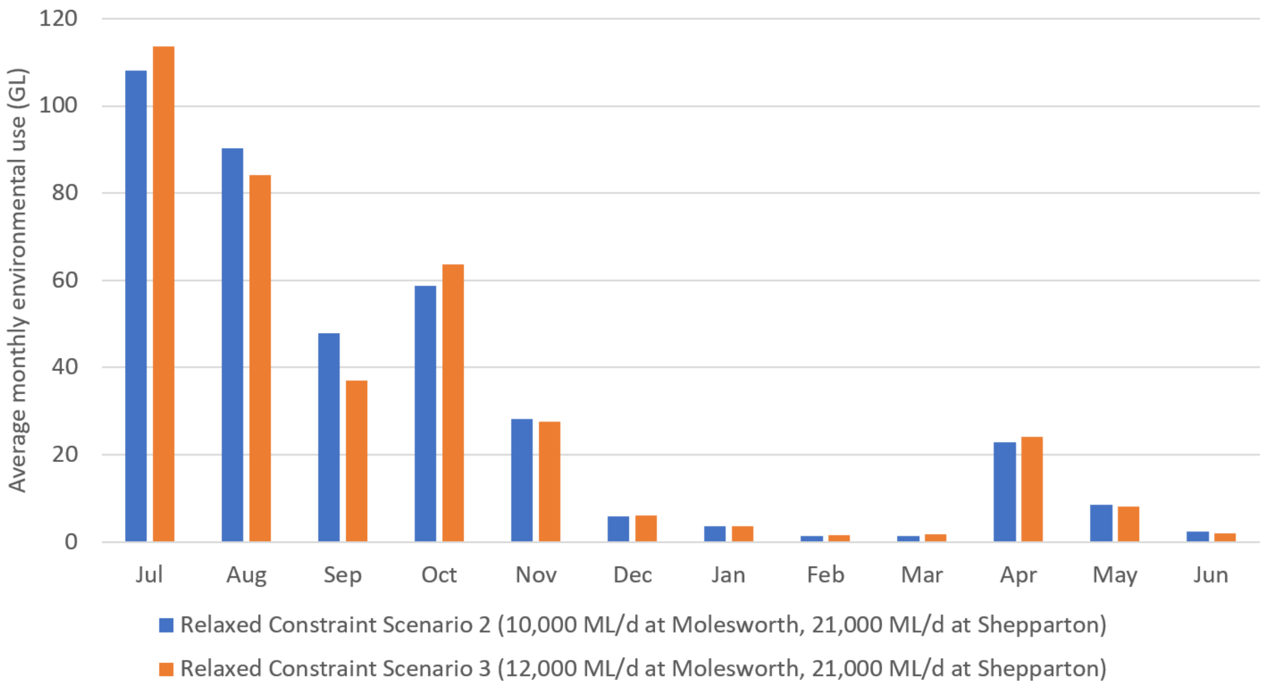

Figure 5: Average Monthly Environmental Use under Relaxed Constraints Scenarios 2 and 3

A comparison of success frequency was also undertaken between Scenarios 5 and 4 (M12L25 and M14L25), as shown in Table 12 below. This comparison shows the additional 2,000 ML/d release from Eildon to be most valuable in helping to meet the 20,000 ML/d target. Winter fresh success criteria require the flow to reach 80% of the target flow rate for 40% of the target duration, so for the 20,000 ML/d target, flow must be greater than 16,000 ML/d for at least 2 days for the event to be considered successful. Under Scenario 5, with a maximum release of 12,000 ML/d from Eildon, there must be a further 4,000 ML/d of tributary inflows for two days to ensure success of the event. Under Scenario 4, with a maximum release of 13,700 ML/d from Eildon, only 2,300 ML/d of additional inflow is required to meet the success criteria.

Table 12: Winter Fresh Success Rates for Relaxed Constraint Scenarios 4 and 5

Winter Fresh Target[1]	Scenario 5 (M12L25)			Scenario 4 (M14L25)		
	Years Targeted	Years Successful	% Successful	Years Targeted	Years Successful	% Successful
15,000 ML/d for 5 days[2]	20	15	**75%**	18	14	**78%**
20,000 ML/d for 5 days[3]	29	12	**41%**	31	17	**55%**
25,000 ML/d for 5 days[4]	76	39	**51%**	76	40	**53%**
All targets	125	66	**53%**	125	71	**57%**

[1] *Winter fresh success criteria: 80% of target, 40% of duration*

[2] *Winter fresh target under Dry and Drought water availability scenarios.*

[3] *Winter fresh target under Below Average water availability scenario.*

[4] *Winter fresh target under Average and Wet water availability scenarios is 30,000 ML/d, but target is limited to lower Goulburn constraint of 25,000 ML/d for Scenarios 5 and 4.*

4.2 Climate Change Scenarios

Two constraint scenarios were run under varying climate conditions to assess the implications of climate change on water delivery. The initial scenarios considered were Current Constraints and Relaxed Constraint Scenario 1 (M10L17: 10,000 ML/d at Molesworth, 17,000 ML/d at Shepparton), however climate change impacts are still being assessed, and additional constraint scenarios modelled under climate change are recommended as part of future work.

The following climate scenarios were used to assess the implications of climate change:

- Historic climate conditions
- Post-1975 climate conditions
- 2070 medium climate change
- 2070 high climate change

Figure 7 shows the change in environmental water availability and use under each of these climate scenarios for Current Constraints, while Figure 7 shows Relaxed Constraint Scenario 1. For both constraint scenarios there is no significant change in use between historic, post-1975 or 2070 medium climate change conditions, however the volume of environmental water spilled and forfeited decreases under the drier scenarios. This indicates that under these scenarios, the constraints and environmental demand assumptions are the main factors limiting environmental use, rather than water availability.

In contrast to this, almost all of the available environmental water is utilised under the 2070 high climate change scenario (90% under Current Constraints, 96% under Relaxed Constraint Scenario 1), indicating that water availability is the major limiting factor. This suggests that under 2070 high climate change conditions, relaxing constraints above 17,000 ML/d at Shepparton is not going to improve long-term utilisation with the current level of environmental entitlements.

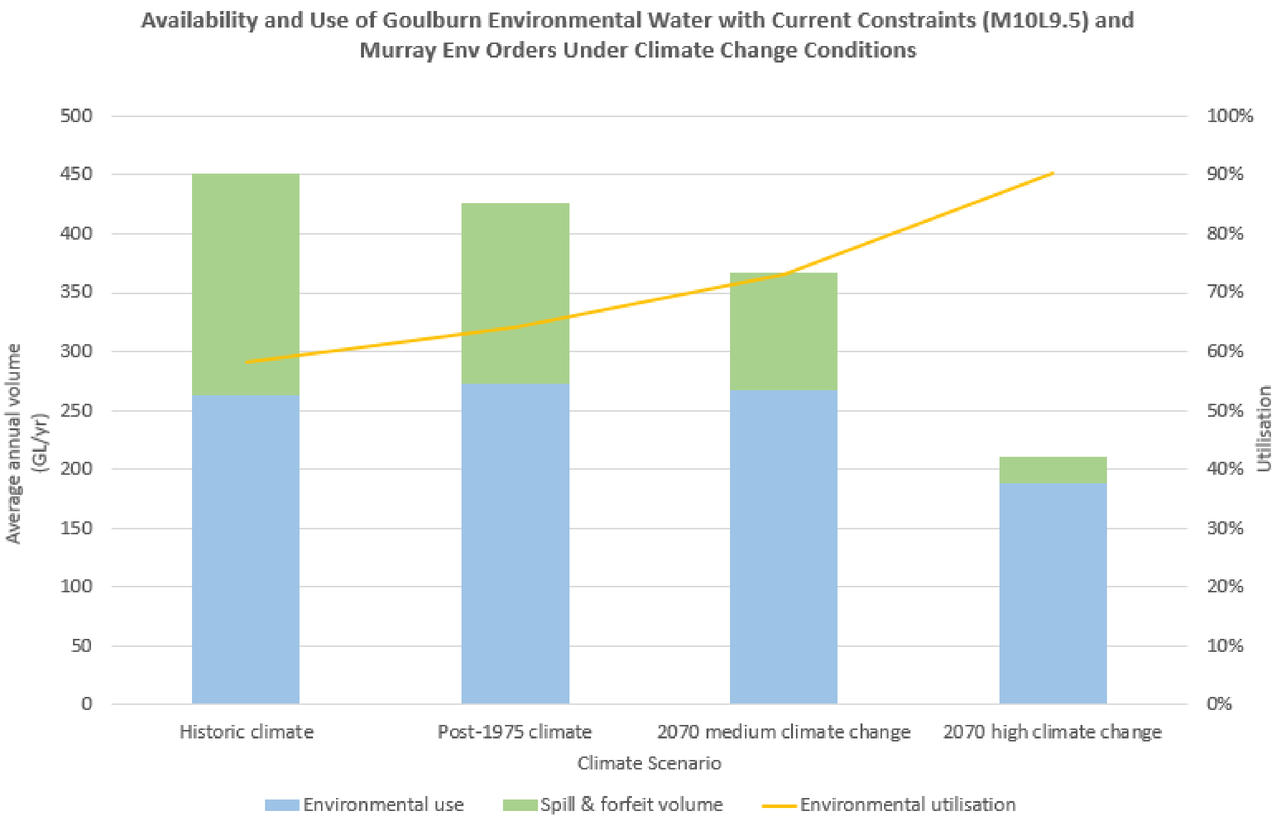

Figure 6: Environmental Water Availability and Use under Current Constraints (M10L9.5) and Climate Change Conditions

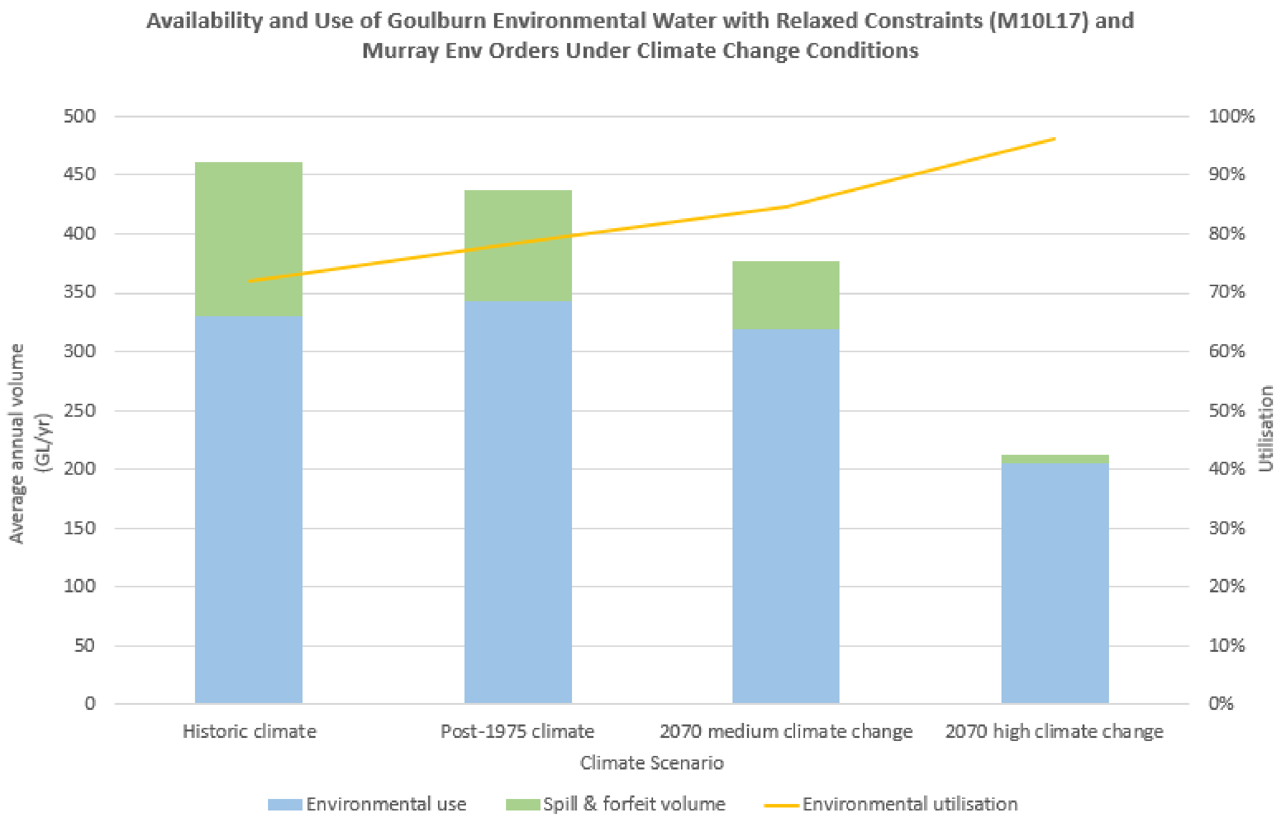

Figure 7: Environmental Water Availability and Use under Relaxed Constraint Scenario 1 (M10L17) and Climate Change Conditions

4.3 Key Modelled Outcomes

The following points summarise the key conclusions that can be made from the modelled scenarios:

- Relaxing the lower Goulburn constraint allows increased utilisation of the environmental water portfolio to meet lower Goulburn environmental needs.
- Relaxing the mid-Goulburn constraint increases the ability to meet large flow targets in the lower Goulburn.
- Reduced water availability under the 2070 high climate change scenario means that relaxing the lower Goulburn constraints above 17,000 ML/d is not going to improve long term utilisation with the current level of environmental entitlements. There is some scope to increase utilisation under the post-1975 and 2070 medium climate change scenarios by further relaxing the lower Goulburn constraint.

5 References

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