Department of Climate Change, Energy, the Environment and Water

Analysis of the Connectivity Expert Panel Recommendations:

Hydrologic modelling assessments

September 2025

NSW GOVERNMENT

Acknowledgement of Country

Department of Climate Change, Energy, the Environment and Water acknowledges the traditional custodians of the land and pays respect to Elders past, present and future.

We recognise Australian Aboriginal and Torres Strait Islander peoples' unique cultural and spiritual relationships to place and their rich contribution to society.

Artist and designer Nikita Ridgeway from Aboriginal design agency – Boss Lady Creative Designs, created the People and Community symbol.

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1 Glossary of terms

EWA	Environmental Water Allowance
GL/y	Gigalitres per year (1 GL = 1,000 ML)
IQQM	Integrated Quantity Quality Model
ML/d	Megalitres per day (flow rate)
RWS	Regional Water Strategy

Executive summary

The Minister for Water convened the Connectivity Expert Panel (the Panel) in 2023 to review the work the Department of Climate Change, Energy, the Environment and Water (the department) has done, and provide independent expert ideas on ways to deliver better water management and environmental outcomes for the Barwon-Darling system.

The Panel provided its final report to the Minister for review and consideration in July 2024. The Panel's recommendations included objectives and a proposed approach for improving flows into the Barwon-Darling River in dry and non-dry times.

The Panel recommended that the department should implement rules in water sharing plans to achieve proposed targets and triggers that aim to:

- During non-dry times – ensure that baseflow is protected across the northern Basin and provide for small and large freshes consistent with the environmental water requirements outlined in the relevant long term water plan. Baseflows should be achieved through minimum daily flow rules at the end of systems, floodplain harvesting access restrictions when supplementary take is not allowed, and dam releases where necessary to achieve the end of system flows
- During dry times – extend the current resumption of flow rules into the northern Basin tributaries and provide for a small flushing flow following an extended dry period all the way to Menindee Lakes prior to allowing extraction. Baseflow end of system flow targets would remain in place and be met to the extent possible with uncontrolled flows, but dam releases to meet these targets would be suspended
- Establish a 'connectivity' environmental water allowance in the Gwydir, Namoi and Border Rivers regulated water sharing plans to provide for replenishment flows during dry times to maintain system health and water quality, following additional analysis of volume needs, benefits and impacts.

These recommendations have been made independent of government and are not government policy. They will be one of the multiple factors taken into consideration when determining what changes need to be made to the way water is managed to improve downstream connectivity outcomes.

Before any decisions are made on next steps, the government has completed analyses to understand the hydrologic, environmental and economic benefits and impacts of the Panel's proposals. This report describes the hydrologic assessments that were completed to assess the Panel's recommendations. All assessments were completed using the latest approved version of the models.

The report provides an overview of changes in river flows in northern inland NSW, and the resulting changes to storage volumes at Menindee Lakes from implementing the rules. It also includes an assessment of changes in diversions by licenced water users in the regulated Border Rivers, Gwydir, Namoi and Macquarie rivers and the Barwon-Darling River below Mungindi and upstream of Menindee Lakes.

The outcomes of the hydrologic assessment have been used to inform the assessment of the environmental and economic benefits and impacts. The results of these analyses are presented in

separate reports. It is important to note, that the analyses presented in these reports do not represent a government response to the Panel's recommendations.

Along with the overarching information report, these reports form the package of documents released[1].

We will meet with key stakeholders to discuss the findings of the analyses and hear their input and issues. We will use these discussions and further analysis to develop the government options for improving connectivity leading on from the Panel's recommendations. These options will be released for consultation in 2026.

Hydrologic modelling completed and results

The updated models have been used to develop the following model scenarios. The assessment includes different approaches (scenarios) to implementing the rules to achieve the Panel's objectives:

- **base case.** A representation of the current conditions and water sharing plan rules.
- **extended resumption of flow.** The Panel proposed restriction on lifting triggers were modelled for:
  - trigger sites proposed by the Panel, which includes **3 new trigger sites** at Mungindi, Collarenebri and Louth in addition to the triggers existing Barwon-Darling water sharing plan trigger sites at Walgett, Brewarrina, Bourke and Wilcannia
  - **existing trigger sites** in the Barwon-Darling water sharing plan.
- **end of system flow** targets. Two approaches for making dam releases to support achievement if end of system target were modelled:
  - dam releases made from a new **high security account**
  - dam releases achieved by **translucency releases** (releases limited to a proportion of inflows).
- **connectivity environmental water allowance** (EWA) to provide for replenishment releases made from a new high security account during dry times. Two approaches for triggering the release of replenishment flows were modelled:
  - replenishment flow release triggered by low **dam inflows**
  - replenishment flow releases triggered by low **flow conditions at Bourke.**
- A **combination scenario** that included the extended resumption of flow (Panel sites), end of system – translucency and, connectivity EWA – Bourke flow trigger was also modelled. This provides an example of the benefits and impacts if the Panel's recommendations were implemented together.

The department has also undertaken further modelling in addition to the recommendations made by the Panel to assess:

[1] These reports are available at: Northern Basin Connectivity Program | NSW Government Water

- the change in the volume of water stored in Menindee Lakes under the scenarios described above
- the effects of combining restrictions when Menindee Lakes fall below critical levels with the extended resumption of flow.

All the modelled scenarios were developed by the department, with the exception of the connectivity EWA - Bourke trigger, which was developed with input from other government agencies. The scenarios were built on previous modelling of scenarios to improve connectivity outcomes that was done for the Western Regional Water Strategy, as well as preliminary modelling to inform the Panel's final report.

A summary of the impacts to long-term average diversions are shown in Table 1, which shows that the combination scenario has the most impact on long-term water use, with the following exceptions:

- the largest impact for the NSW Border Rivers arises from the end of system – high security accounts due to the much larger end of system target proposed for the Border Rivers relative to the other valleys, and the consequent volume required for the associated high security account
- the largest impact for the Gwydir River regulated river system arises from the extended resumption of flow rule combined with restrictions when the Menindee Lakes storages are low. This is due to the combined effect of the high reliance on supplementary access and floodplain harvesting in the Gwydir and the effect of the additional sites for determining restrictions to access under the proposed extension of the resumption of flow rules[2].

The potential benefits from the Panel's recommendations to storage volumes at Menindee Lakes has also been assessed, with the changes in storage volumes shown in Figure 1 and Figure 2, indicating that:

- there would be some improvements in the volume of water in storage, even at higher storage levels (Figure 1)
- focussing on higher exceedances (drier conditions) in Lakes Wetherell and Pamamaroo that are important for supply to the Lower Darling River during drought periods Figure 2, shows that not including restrictions based on Menindee Lakes:
  - there are most improvements in storage volumes under the combination scenario, although the difference is smaller at the very high exceedance levels (driest conditions) and other scenarios can provide slightly more improvement at times
  - the combination scenario, with the largest improvement, would result in the active storage in the upper lakes exceeding 250 GL approximately 5% of the time more than in the base case, with all other scenarios falling between these.

[2] Restrictions based on Menindee Lakes is not a recommendation of the Panel. The Panel recommended that once the Government has determined which of the Panel's rules are intended to be implemented and the likely contribution of those rules, as well as any changes to held environmental water, further analysis should be undertaken regarding the potential need for any additional flows into the Menindee Lakes. Restrictions to floodplain harvesting access when Menindee storages reduce to critical levels is a current provision in the Namoi water sharing plan

Table 1. Summary of impacts to long-term average annual diversions from each model scenario (1895-2023)

Scenario		Base Case	Extended RoF*	EoS - translucency	EoS -HS account	Connectivity EWA– Bourke	Connectivity EWA - dam	Combination**
Border Rivers	Diversions (GL/y)	214.2	207.0	205.6	161.4	207.4	187.2	195.9
	Change (GL/y)		-7.2	-8.6	-52.8	-6.8	-27.0	-18.3
	Change (%)		-3.4%	-4.0%	-24.6%	-3.2%	-12.6%	-8.5%
Gwydir	Diversions (GL/y)	446.2	420.8	436.1	422.4	442.6	431.9	408.8
	Change (GL/y)		-25.4	-10.1	-23.8	-3.6	-14.2	-37.4
	Change (%)		-5.7%	-2.3%	-5.3%	-0.8%	-3.2%	-8.4%
Namoi	Diversions (GL/y)	252.6	239.3	247.4	242.0	246.9	232.7	229.7
	Change (GL/y)		-13.3	-5.2	-10.6	-5.7	-19.9	-22.9
	Change (%)		-5.3%	-2.1%	-4.2%	-2.3%	-7.9%	-9.1%
Macquarie	Diversions (GL/y)	330.2	327.2	N.A.	N.A.	N.A.	N.A.	327.6
	Change (GL/y)		-3.0	N.A.	N.A.	N.A.	N.A.	-2.6
	Change (%)		-0.9%	N.A.	N.A.	N.A.	N.A.	-0.8%
Barwon -Darling	Diversions (GL/y)	171.3	164.9	172.4	173.3	172.2	173.4	167.8
	Change (GL/y)		-6.4	+1.0[#]	+1.9[#]	+0.9[#]	+2.1[#]	-3.6[#]
	Change (%)		-3.7%	+0.6%[#]	+1.1%[#]	+0.5%[#]	+1.2%[#]	-2.1%[#]

* This table only presents the results for extended resumption of flow which includes the additional trigger locations recommended by the Panel. The results of analysis of extended resumption of flow using the existing trigger locations in the Barwon-Darling water sharing plan are presented in section 4 and the results of the extended resumption of flow and Menindee restrictions are presented in section 8.

** The combination scenario has modelled together the extended resumption flow, end of system - translucency, and connectivity EWA- Bourke

[#] It is intended that additional environmental flows into the Barwon-Darling under these scenarios would be protected. However, this could not be included in this modelling and unintended small increases in diversions have occurred. The results reported will therefore under-estimate the improvements in flows along the Barwon-Darling and under-estimate impacts to Barwon-Darling water users.

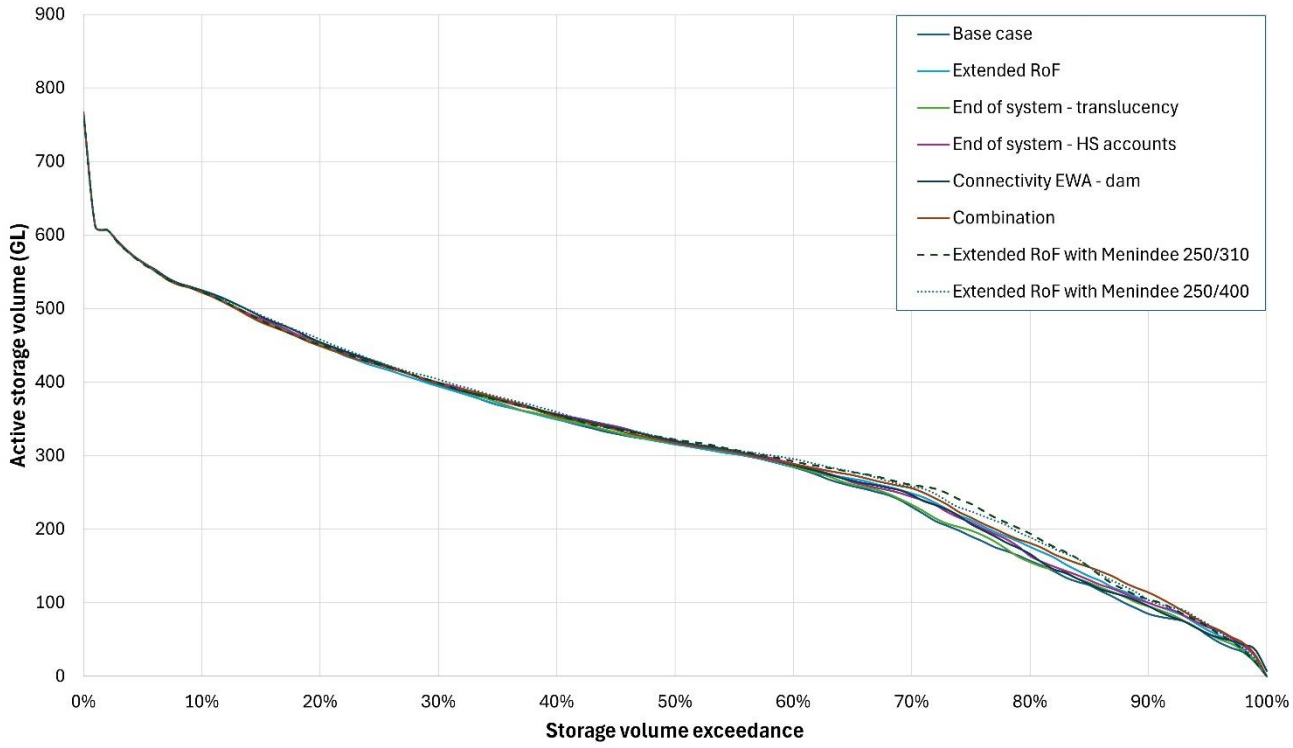

Figure 1. Upper Menindee Lakes (Wetherell and Pamamaroo) storage volume exceedance (proportion of time the storage is higher than a volume)

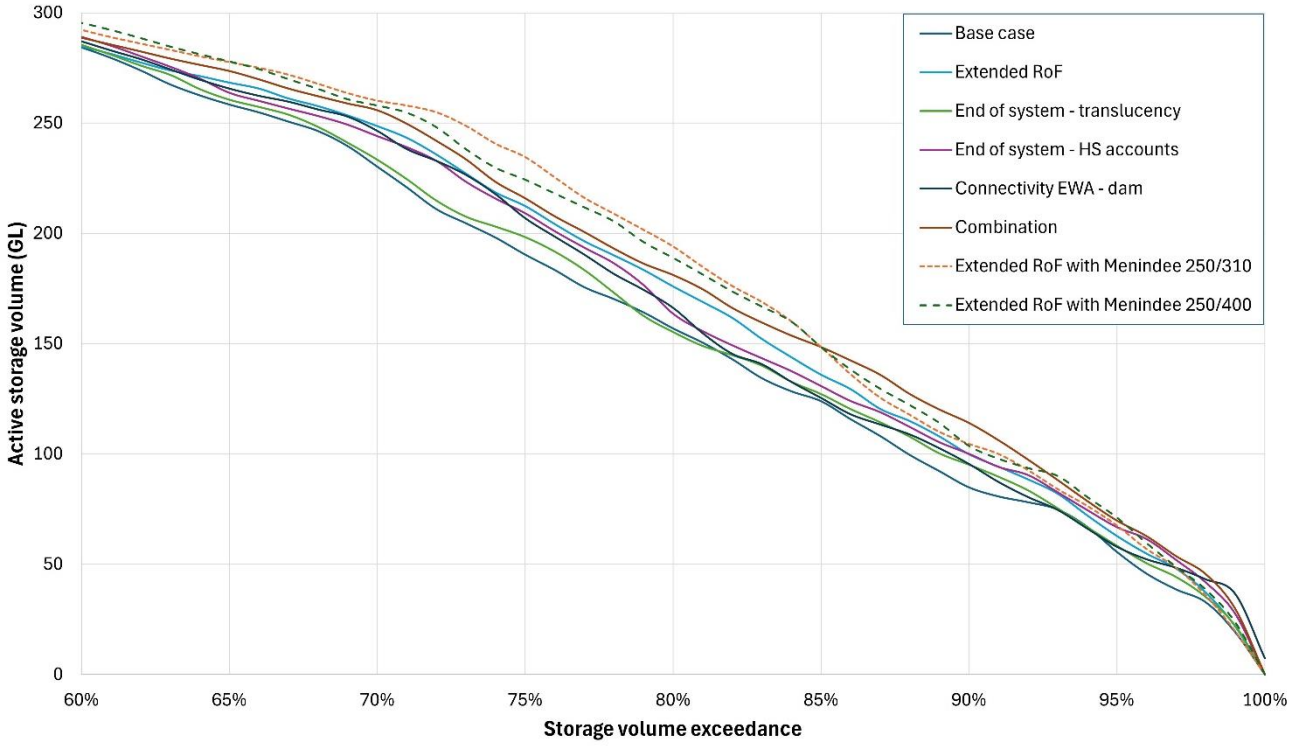

Figure 2. Upper Menindee Lakes (Wetherell and Pamamaroo) storage volume exceedance (proportion of time the storage is higher than a volume) – focus on drier exceedance conditions

1 Introduction

1.1 Background

The NSW Government is committed to improving river connectivity into the Barwon-Darling River based on science, to protect downstream critical human needs and achieve improved environmental outcomes. The Northern Basin Connectivity Program is exploring changes that could be made to flow targets in northern Basin water sharing plans to achieve this.

The Western Regional Water Strategy[3] undertook significant analysis and consultation to better understand potential for water sharing plan changes to provide for critical needs in the Barwon-Darling and downstream. This analysis focussed on dry times to address key recommendations from reviews arising out of events that occurred in the 2017-20 drought. These include the Independent Assessment of the 2018-19 fish deaths in the lower Darling (Vertessy review[4]) and the Independent Panel Assessment of the Management of the 2020 Northern Basin First Flush Event[5].

Before making changes to water sharing plans to implement the connectivity actions identified in the Western Regional Water Strategy, the Minister for Water established the Connectivity Expert Panel (the Panel) to review the analyses the Department of Climate Change, Energy, the Environment (the department) has undertaken and provide and independent assessment of its adequacy.

1.2 Panel's objectives and proposed approach for improving connectivity

The Panel provided its final report[6] to the Minister for review and consideration in July 2024. The Panel's recommendations included objectives and a proposed approach for improving flows into the Barwon-Darling River in dry and non-dry times.

The Panel recommended that the department should implement targets and triggers that aim to:

a. *During non-dry times – ensure that baseflow is protected across the Northern Basin and provide for small and large freshes consistent with the environmental water requirements outlined in the relevant long-term water plan. Baseflows should be achieved through minimum daily flow rules at the end of systems, floodplain harvesting access restrictions*

[3] Department of Planning and Environment (2022) *Western Regional Water Strategy*. Western Regional Water Strategy | NSW Government Water

[4] Independent assessment of the 2018-19 fish deaths in the lower Darling

[5] Independent Panel Assessment of the Management of the 2020 Northern Basin First Flush Event

[6] Dula, A., Duncan, P., Sheldon, F., Smith, C., Southwell, M., and Townsend, P. (2024). *Connectivity Expert Panel Final Report, July 2024*. Northern Basin Connectivity Program | NSW Government Water

when supplementary take is not allowed, and dam releases where necessary to achieve the end of system flows.

b. *During dry times – extend the current [*Barwon-Darling*] resumption of flow rules into the Northern Basin tributaries and provide for a small flushing flow following an extended dry period all the way to Menindee Lakes prior to allowing extraction. Baseflow end of system flow targets would remain in place and be met to the extent possible with uncontrolled flows[7], but dam releases to meet these targets would be suspended.*

c. *Establish a 'connectivity' environmental water allowance in the Gwydir, Namoi and Border Rivers regulated water sharing plans to provide for replenishment flows during dry times to maintain system health and water quality, following additional analysis of volume needs, benefits and impacts.*

The panel proposed that there should be a trigger to transition from non-dry to dry times rules as part of the end of system flow rule. Once the dry time trigger is met, releases from the dam to meet and of system flow targets would be suspended though restrictions to take of supplementary and floodplain harvesting would remain if the end of system target is not being met. The targets and triggers associated with the Panel proposed rules are included in Appendix A[8].

The Panel envisaged that these rules would work together to improve system connectivity across a range of climatic conditions.

It is important to note that the Panel's recommendations have been made independent of government and are not government policy. They will be one of the multiple factors taken into consideration when determining what changes need to be made to the way water is managed to improve downstream connectivity outcomes.

The department has completed the initial analysis of potential water sharing plan rules that would result in the implementation of the Panel's recommendations to understand the potential hydrologic, environmental and economic benefits and impacts. The analysis provides an initial assessment of how implementing the Panel recommendations may change water availability for the environment and water users.

1.3 Previous connectivity modelling

Previous modelling of connectivity options completed for the Western Regional Water Strategy[9] and for the Panel[10] used inflows to each river system model that were completely generated by rainfall runoff modelling and did not use observed inflows. This approach provided consistency between

[7] Uncontrolled flows is water that is not captured in dam but can be made available for extraction. These uncontrolled flows occur due to rainfall events, rather than dam releases.

[8] Due to time constraints, there was only limited modelling done to inform the targets and triggers recommended be the Panel.

[9] Western Regional Water Strategy - hydrologic analysis of options Western Regional Water Strategy engagement | NSW Government Water

[10] see Appendix F of Connectivity Expert Panel Final Report. Northern Basin Connectivity Program | NSW Government Water

modelling of the period of historic period of climate records and the modelling of the much longer stochastically generated climate sequences and climate change sequences that was developed for the Regional Water Strategies program. However, the use of observed inflows wherever available is the currently agreed modelling approach under water sharing plans and water resource plans.

The river system models used for Regional Water Strategies in the northern basin were the most recent available in 2021 to support the program of work for developing strategies for each valley and included the upgrading of river system models to represent floodplain harvesting[11]. To provide stability for the Regional Water Strategy program, the base models being used remain unchanged from 2021. However, since that time, some models have been developed further, and the Source model for the Namoi regulated river system has been significantly upgraded and recalibrated.

Modelling in this report is an update on earlier modelling with updated models and methods and uses observed inflows. It is important to note that the results in this report are not directly comparable to earlier connectivity modelling results.

1.4 Scope of this assessment

This report describes the hydrologic assessment that was completed to assess the Panel's recommendations. This assessment includes different approaches to implementing the proposed rules to achieve the Panel's objectives. This will help building understanding of which approaches would achieve the Panel's proposed outcomes while minimising impacts on diversions and inform stakeholder feedback on how the Panel's proposed rules could be implemented more effectively. In line with Panel recommendations, the hydrologic modelling has used observed inflows[12] and the latest versions of each valley model, as described in Section 2.

The report provides an overview of changes in river flows in northern inland NSW, and the resulting changes to storage volumes at Menindee Lakes from implementing the rules.

The outputs of the hydrologic modelling have been used to inform the assessment of the benefits and impacts of panels proposals are changes in river flows and changes in licensed diversions (Figure 3). This report presents the results of the latest hydrologic analysis of the impacts of the Panel's proposed flow targets on diversions by licensed water users in the regulated NSW Border Rivers, Gwydir, Namoi, and Macquarie rivers, and on diversions by licensed water users along the Barwon-Darling River system below Mungindi and upstream of Menindee Lakes.

The outcomes of the hydrologic assessment have been used to inform the assessment of the environmental and economic benefits and impacts Figure 3. The results of these analyses are presented in separate reports[13].

[11] see model build and scenario reports for NSW Border Rivers, Namoi, Gwydir, Macquarie River and Barwon-Darling Licensing floodplain harvesting | NSW Government Water

[12] Observed inflows are not available for all of the period for which observed climate and river flow data are available, and observed inflows have always been extended or gap-filled with rainfall runoff modelled inflows

[13] These reports can be accessed at Northern Basin Connectivity Program | NSW Government Water

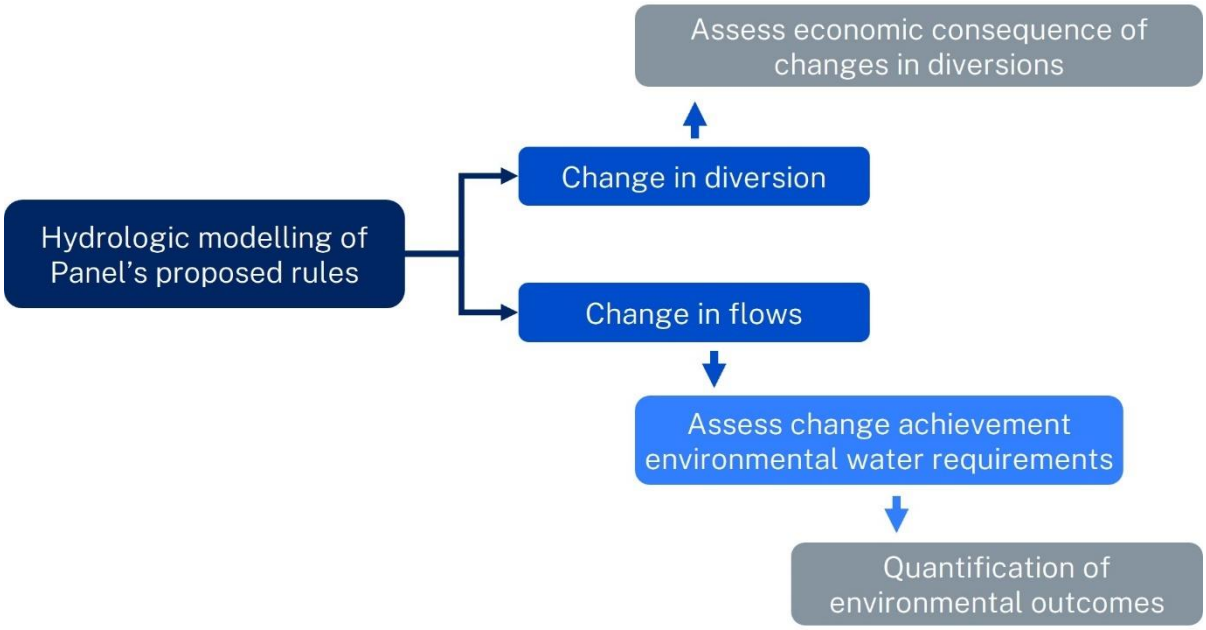

Figure 3 Overview of the analyses that have been done to assess the benefits and impacts of the Panel's recommendations

The modelling of the regulated rivers and the Barwon-Darling use observed tributary inflows extended with rainfall runoff modelling where observed data is not available. This means that the impacts of water use in tributary rivers and streams (where flows are not regulated by major storages to support water use) is reflected in the observed outflows. However, any proposed changes to access for water users in unregulated streams is not currently able to be reflected in the tributary inflows used by the models.

The proposals to improve northern basin connectivity also provide additional inflows to Menindee Lakes. To explore the potential improvements in water storage at Menindee Lakes that might occur with each model scenario, the results of this modelling have been used as an input to the Source model of the Murray and Lower Darling River system prepared by the Murray Darling Basin Authority to assess the potential benefits from the Panel's recommendations to storage volumes at Menindee Lakes.

The department is releasing the results of this initial analysis of the Panel's recommendations. It is important to note that these analyses do not represent a government repones to the Panel's recommendations.

The department we will now meet with key stakeholders to discuss findings and hear their input and issues. We will use these discussions and further analyses to help develop government options for improving connectivity leading on from the Panel's recommendations. These options will be released for consultation in 2026.

Reports can be accessed at: Northern Basin Connectivity Program | NSW Government Water.

2 Assessment framework

2.1 Modelling objectives

The Panel recommendations included objectives and a proposed approach for improving flows into the Barwon-Darling River in dry and non-dry times. These proposals include flow targets and triggers that could be incorporated into water sharing plans to achieve their objectives (Appendix A).

Hydrologic modelling has been completed to inform assessment of the benefits and impacts of making changes to water sharing plans to achieve the outcomes and objectives proposed by the Panel. This includes some additional investigation of matters recommended by the Panel.

The hydrologic modelling provides information:

- on change in flows at gauges. This information has been used assess change in achievement of environmental water requirements[14].
- change in water that can be extracted by each licence type, this information is presented in this report.

2.2 Modelled scenarios

The department has modelled potential rules that would result in the implementation of the Panel's recommended objectives and proposed approach for improving connectivity. These have been modelled as individual model scenarios by modifying a base case scenario representing current conditions in each valley and comparing the results against the model base case.

Table 2 provides an overview of the modelling that has been completed. For some of the recommendations, the department has assessed alternative approaches of how potential water sharing plan rules could be implemented. This will help build understanding of which approaches would achieve the flow targets while minimising impacts on diversions.

All the modelled scenarios were developed by the department, with exception of the connectivity environmental water allowance (EWA)– Bourke flow trigger which was developed with input from the Connectivity Interagency Working Group[15]. The scenarios built on previous modelling of scenarios to improve connectivity outcomes that was done for the Western Regional Water Strategy, as well as preliminary modelling to inform the Panel's final report.

[14] Analysis of Connectivity Expert Panel Recommendations. Attachment 2: assessment of environmental water requirements. Northern Basin Connectivity Program | NSW Government Water

[15] Connectivity Interagency Working Group Terms of Reference. Northern Basin Connectivity Program | NSW Government Water

Table 2. Overview of the hydrologic modelling completed to inform the assessment of the Panel's recommendations

Panel recommendation	Potential rules modelled
Model base case	A representation of the current conditions and water sharing plan rules[16]. It includes any policies or initiatives that are agreed or in the process of being implemented It is used as the comparison point for modelled scenarios.
The resumption of flow rules should be extended into the northern tributaries to protect a small fresh all the way through the system down to Menindee Lakes, following an extended dry period.	Modelled scenario was based on a modification and extension of the existing Barwon-Darling Water Sharing Plan resumption of flow rule into the tributary valleys with the triggers proposed by the Panel: • trigger for imposing restrictions is flows falling below the baseflow rate for 90 days • trigger for lifting restrictions is flows above the small fresh flow rate for 14 days • Removing the 30 GL cumulative flow trigger at Bourke for lifting restrictions. Two approaches were modelled • **extended resumption of flow** uses the three new trigger sites at Mungindi, Collarenebri, and Louth as proposed by the Panel in addition to the trigger locations specified in the Barwon-Darling water sharing plan (Walgett, Brewarrina, Bourke, Wilcannia) • **extended resumption of flow- existing sites** uses the resumption of flow trigger locations specified in the Barwon-Darling water sharing plan (Walgett, Brewarrina, Bourke, Wilcannia) Restrictions were applied to the Border Rivers, Gwydir, Namoi, and Macquarie regulated valleys and the Barwon-Darling.
Set an end of system flow target in regulated valleys to protect baseflows Regulated river water sharing plans should have an end-of-system flow requirement, equivalent to the bottom of baseflow, to enable baseflow targets in the Barwon-Darling to be achieved in non-dry times. The end of system flow should be achieved through limitations on	Water sharing plans already contain restrictions for the announcement of supplementary access that largely provide for the end of system flow targets to be met, and no additional restrictions have been modelled. Implementation of end of system flow targets, equivalent to the bottom of the range of baseflows environmental watering requirement for the NSW Border Rivers, Gwydir, and Namoi regulated rivers. Two approaches for making dam releases to meet the end of system target were modelled:

[16] The model base case for the Border Rivers, Gwydir and Namoi do not include the north-west flow plan that are currently in the regulated water sharing plans for these valleys as they have not been implemented. They rely on flow forecasting, and the accuracy of this is insufficient to support requirements for use.

Panel recommendation	Potential rules modelled
supplementary and floodplain harvesting access in the first instance, with releases made from storage if these flows are not adequate. Requirement to make dam release would be suspended in dry times, though restrictions to supplementary and floodplain harvesting remain	• **end of system - high security account:** dam releases were made from a new high security account. • **end of system – translucency:** a proportion of the daily dam inflow is released to meet the end of system target. The amount released is capped by dam inflows. For both approaches, releases were not made in periods where the rolling 30-day average dam inflows fell below the 75th percentile (the dry inflow trigger).
Connectivity environmental water allowance (EWA) The Gwydir, Namoi and Border Rivers regulated water sharing plans should include a 'connectivity' EWA to provide pulses as needed for water quality and other environmental outcomes during dry times. At a minimum, provide for reconnecting pools for critical human water needs, environmental needs and water quality needs during dry times.	The connectivity EWA would provide for replenishment releases to be made from storage dams to (at a minimum) provide for reconnecting pools for critical human, environmental and water quality needs during severe dry times. Two approaches for implementing the connectivity EWA were modelled: • **connectivity EWA - dam inflows trigger** — replenishment releases are triggered on 31 October and/or 28 February, if the inflows to the dam are less than the 75th percentile dry trigger — replenishment releases are made over a 20-day period at the operational channel capacity at the lower end of each system (approximately 800 - 1,000 ML/day, depending on location). • **connectivity EWA - Bourke flows trigger** — replenishment release triggered when flows at Bourke are below 450 ML/d for 120 consecutive days — target for release was to achieve a flow of 500 ML/d for 14 days at Bourke — to achieve the flow outcomes at Bourke the models were configured to order 500 ML/day at the end of each regulated tributary. Storage releases were staggered to allow for travel time to Bourke. For both approaches, a new high security account was established to provide water for releases.

The department has also completed modelling to address recommendations and statements in the panel's report relating to the need to do combined analysis of approaches, and Menindee Lakes (Table 3).

Table 3 Additional scenarios modelled to assess other Panel recommendations and statements

Panel Recommendation	Modelled Scenarios
Rules have been modelled in isolation Any future connectivity impact analysis should seek to examine the suite of proposals as a package to fully estimate the overall and combined effects of water access restrictions to improve connectivity.	The combination scenario was done to provide an illustration of how the flow targets may work together. The approaches included in the combined scenario and reason they were selected by the department for inclusion are: • extended resumption of flow (Panel sites: selected as Panel recommended inclusion of these additional trigger sites • end of system flow – translucency: selected as it has more even diversions impacts across the valleys than the high security accounts approach • connectivity environmental water allowance – Bourke flow trigger: selected as it is the approach closest to the intent of the Panel's recommendation Note that the Macquarie valley only has the resumption of flow rule applied. It should be noted that the inclusion of these scenarios in the combined run does not indicate any preference for progressing that scenario over another.
Menindee targets The Panel's report included recommendations in relation to management of Menindee Lakes and recommended that once these recommendations be implemented further analysis be undertaken on whether a trigger for refilling the upper Lakes is warranted.	Modelling has assessed the change in inflows into Menindee lakes from the implementation of each of the resumption of flow, end of system targets and connectivity EWA options. This scenario was modelled to assess if restrictions in addition to the extended resumption of flow (Panel trigger sites) would be required to refill the upper Lakes once they fall below 250 GL active storage in the upper lakes[17]. The combined scenario modelled included: • Menindee 250/310 — restrictions commence when upper lakes fall below 250 GL active storage — restrictions cease when active volume in the upper lakes rises above 310 GL (this equates to triggers in Western Regional Water Strategy, if Pamamaroo inlet is not repaired)

[17] Menindee restriction triggers use the active volume in Lakes Wetherell and Pamamaroo, which are the upper two lakes in the Menindee lakes system (referred to as the top lakes). This includes the connected smaller lakes known as Lake Tandure (connected to Lake Wetherell), and Copi Hollow (connected to Lake Pamamaroo).

Panel Recommendation	Modelled Scenarios
	• Menindee 250/400: — restrictions commence when upper lakes fall below 250 GL active storage — restrictions cease when active volume in the upper lakes rises above 400 GL (this equates to full supply capacity in the upper lakes).

2.3 Model results presented

Results from the modelling of each scenario have been presented to provide the following information:

- long-term: We have presented long-term average annual use across the whole modelled climate period from 1895 – 2023 to provide an overall measure of change. This has been assessed in water years (1 July – 30 June) for the following:
  - total regulated river system licensed diversions, including all categories of water use have been included
  - water by each category of licensed water use.
- annual: we have presented annual diversions by water year for the base case with the changes in diversions under each scenario to show the variation in changes across water years.
- we have also presented the modelled storage volumes at Menindee Lakes to show how each of the Panel's proposals would change the storage volumes over the longer term, and how they might have changed storage volumes during the recent drought period from 2017 – 2020.
- for relevant scenarios, the periods of restriction to supplementary, floodplain harvesting and Class A/B/C access have been shown, including in relation to base case periods of restriction where relevant.
- floodplain harvesting volumes have been reported as the sum of overbank flow harvesting and both exempt and non-exempt rainfall runoff harvesting, to ensure that the results reflect the combined effect of proposed rules on all forms of access

Water use by towns and basic landholder rights have not been shown separately. Water use by towns in regulated river systems are not affected by scenarios investigated in this report and, although water access would improve to some degree for towns along the Barwon-Darling, they are not represented in the model. Similarly, water use by basic landholder rights is too small to be included in the models and is generally included in the calibrated flow losses. Whilst basic landholder rights are not modelled explicitly, we could infer improvements due to flows occurring for longer and at higher rates.

Reporting of model results in relation to environmental outcomes and economic analysis are shown in separate companion reports[18].

2.4 Model assumptions and limitations

There are some processes that are currently occurring in the northern Basin that are relevant to understanding the existing level of connectivity between the main tributary river systems and the Barwon-Darling River that are not yet represented in river system models.

This includes:

- water recovery under the Basin Plan and its use to achieve environmental outcomes
- any flows reaching or returning to rivers as a result of the licensing[19] of floodplain harvesting or any other restrictions applied in model scenarios
- the protection of held environmental water flowing in the Barwon-Darling and Lower Macquarie under the active management process and
- representation and protection of additional flows from Queensland arising from water recovery under the Basin Plan.

River system models have been undergoing continuous development over many decades to meet the evolving needs of water management in the Murray-Darling Basin, and there are model enhancements planned or underway to address the processes noted above that are not yet available. The absence of model enhancements to represent these processes will generally lower the modelled base case flows into and along the Barwon-Darling River, and therefore also lower the flows modelled in each scenario and under-estimate the achievement of the environmental flow requirements set out in long term water plans.

For all river system models, the calibration of river flows, and water losses along the river, tend to perform better for in-channel flows during normal operations that are important for simulating water use well.

Very high and very low flows are more difficult to model, and very low flows can be significantly affected by antecedent conditions and the presence of water holes and small weirs along the river that do not usually have a significant effect on higher flows. This also affects the modelling of inflows to Menindee Lakes during dry periods.

The Barwon-Darling River system is very long and has a significant number of weirs and waterholes that are not explicitly configured in the model. It is apparent that the model currently over-estimates very low flows and does not well represent periods where flows cease along the river. Whilst this is of little importance for simulating irrigation water use along the Barwon-Darling River, it is of more significance for environmental outcomes, stock and domestic access, and water security and amenity along the river.

[18] These reports are available at: Northern Basin Connectivity Program | NSW Government Water

[19] Licensing of floodplain harvesting is yet to occur in the Namoi Valley and is not included in the model used for this assessment. Instead, floodplain harvesting is represented at existing levels, unrestricted by licensing.

The Barwon-Darling River system model is currently modelled using the Integrated Quantity Quality Model (IQQM) platform and is in the process of being transitioned into the Source modelling platform. As part of this process more focus is being given to the calibration of very low flows.

2.4.1 Statement on connectivity modelling reliability

The section below provides a statement from the department on how modelled information is best used to inform decision-making.

Water management in NSW relies on (numerical simulation) models to provide estimates of what water is available, how much is needed, and how the resource can be equitably shared. The department manages the river system models that have been developed for this purpose.

A range of modelling techniques are used to understand how our rivers behave. Models help predict what will happen in a variety of scenarios, including those that test water sharing, compliance, changing climate impacts, and other factors that affect water availability. While the models may have limitations, they enable assessment of the relative benefits and impacts on water users of the various approaches.

The department's hydrologic models are the best available estimate of how these complex systems interact and behave at a specific point in time. As such, they help understand how a system might behave if water were managed differently, or if different rules or decisions were applied. The department reviews input data and calibrates the models themselves to ensure the models represent river systems as faithfully as possible. All models are independently peer reviewed to ensure they are fit for their primary intended purposes in developing water sharing plans and compliance with long term diversion limits.

Model studies are always best at understanding the relative change that might be expected from adding or removing a rule. The absolute number can be incorrect, but in some instances, the model may give a sensible relative response.

Model results have not been bias corrected or post processed to remove known biases. Model results and subsequent analyses should be interpreted with caution including by considering model limitations and biases. There are known limitations of the models in making assessments of low flows due to the model overstating most of the very low flow regime. Some of this low flow error is caused locally within the Barwon-Darling model through mechanisms such as an absence of river pools from the model which mean that after a period of cease to flow, any inflows immediately move through the system, whereas in reality the pools must be successively refilled before flow can recommence.

Much of the excessive low flows in the model originates in upstream models and this excess inflow expresses itself in the Barwon-Darling model as the flow moves through. It is generally unsafe to use the model to make statements such as the expected frequency of cease to flow conditions or the timing of cease to flow conditions. The model generally understands when dry conditions are prevailing and can give some relative guidance on if a proposed action is likely to make dry conditions better or worse, but caution should be used with anything that attempts to get the model to say with a simple metric how dry things are.

In addition, there are related known limitations in modelling low volumes in Menindee Lakes. Due to the focus of the connectivity rules being assessed on low flow characteristics, these limitations should be considered in decision-making.

In the analyses of connectivity rules, there are a number of additional limitations of the models that may tend to overestimate impacts on entitlement holders and underestimate connectivity benefits to an unknown extent.

These include:

- No universal capability to explicitly represent return flows to the system if floodplain harvesting is restricted, noting that floodplain harvesting is not generally occurring during periods of low flow being targeted by the connectivity program.
- The representation of held environmental water demands is inconsistent and varies from full environmental watering programs through to simplistic assumptions of no change compared to previous irrigation uses. It is likely that a full held environmental water representation in the models would indicate improved downstream flow outcomes relative to the base case. This means that the models are likely to overestimate the quantum of intervention required to achieve specific flow targets.
- There have been proposals that irrigation in unregulated areas could be restricted on a similar basis to restrictions on supplementary entitlements or floodplain harvesting entitlements in nearby areas. Examples could be the Mooki River or Lower Pian creek, or the Lower Gwydir. Generally, these unregulated systems are not modelled, and thus it is not possible to represent in a model which we do not have, what the downstream flow benefits could be from the proposed restrictions.
- Active management to protect additional environmental flows in the Barwon-Darling has not been modelled.

The extent to which the limitations of models impact on the validity of assessments of proposed rules cannot be readily quantified. Models are a critical analytical tool in assessing potential rule changes but are not able to provide perfect analysis of outcomes. As such results should be interpreted by those knowledgeable of the limitations. Further multiple lines of evidence should be used where possible to enhance decision-making.

A more detailed discussion of model configuration, assumptions and uncertainty can be found in the model build reports published by the department[20].

[20] Licensing floodplain harvesting | NSW Government Water

3 Model base case

A base case is important for comparison with modelling of various scenarios that have been undertaken. It is intended that the base case represents current conditions, including any policies or initiatives that have been agreed or are currently in the process of being implemented.

In line with Panel recommendations, modelling of proposed flow targets has been completed using the latest version of the river system models that are approved for formal purposes under water sharing plans, such as compliance with long-term average annual extraction limits. Models[21] versions used are provided in Table 4. The modelling has used the observed tributary inflows[22] for each river system model.

Table 4. Models and model versions used in hydrologic assessments

Valley model	version used
Barwon-Darling Valley unregulated river system	7_105_rc1_rev_4612 DarlAPT06_ConBase.sqq (IQQM software)
Border Rivers Valley regulated river system	5.20.0.12549BorderRivers_2023_24_CC_FPHRules_Connectivity_5.20.rsproj (Source modelling platform)
Gwydir Valley regulated river system model	7_105_rc1_rev_4612 vsc_v28_05_2024_s44-1.sqq (IQQM software)
Namoi Valley regulated river system	(Source modelling platform) 5.20.0.12549NAMO_CAL_309_5.20.0.12549.rsproj (Source modelling platform)
Macquarie Valley regulated river system	7_105_rc1_rev_4612 CC_APT_20230322_wembargo_on.sqq (IQQM software)

These base case models also include water entitlements held by government for environmental purposes (known as held environmental water) which are represented as irrigation nodes in the model that extracts the water from the river[23]. This is the model setup used for modelling undertaken by NSW for the development of the water resource plans, which was a representation of current conditions in each valley at that point in time. The use from these licences has been included in the diversion totals reported, unless otherwise indicated.

[21] The model build reports for each of these models can be accessed at: Presenting results | NSW Government Water

[22] Observed inflows are not available for all of the period for which observed climate and river flow data are available, and observed inflows have always been extended or gap-filled with rainfall runoff modelled inflows

[23] For the Barwon-Darling Valley the held environmental water is not modelled as being pumped, and water use has been removed at the irrigation sites in the model where the HEW was purchased

The restrictions to supplementary access for meet Barwon-Darling flow targets originally developed under the interim unregulated flow plan for the north-west are not modelled in the base case. Restrictions to meet these flow targets remain unimplemented due to operational limitations that have not been able to be overcome. The Panel's recommendations have been framed as an alternative to these earlier Barwon-Darling flow targets, and it is considered appropriate that they should be excluded from the base case.

All the river system models used in this analysis have been or are in the process of being reviewed by the Murray-Darling Basin Authority as part of the accreditation of water resource plans and have also been independently reviewed as part of the Healthy Floodplains Program.

The Border Rivers model has been configured with Queensland water use at the sustainable diversion limit levels following Basin Plan implementation, with the demand for water simulated via Queensland's entitlement modelling approach where diversions occur at the maximum permissible rate whenever flows are available until the full entitlement has been taken.

During the transition to the latest approved models, the opportunity was taken to make some specific model enhancements to support the connectivity program. This included enhancing the ability for models to implement restrictions to supplementary and floodplain harvesting access for discrete periods.

A comparison of long-term average diversions under current conditions modelled under the latest approved models with the base case used for the 2024 Panel report[24] and the Western Regional Water Strategy program[25] is shown in Table 5.

Table 5. Total long-term average diversions (1895 – 2020) under the base case in the latest approved models used in the modelling for this report and the base case in rainfall runoff models used in the modelling for the Western Regional Water Strategy (RWS)

Valley	Base case GL/y	Western RWS base case GL/y	Change from Western RWS base case %
Border Rivers	212.8	203.1	+4.7%
Gwydir	441.2	449.5	-1.9%
Namoi	251.4	236.6	+6.3%
Macquarie	324.9	337.1	-3.8%
Barwon-Darling	170.3	161.2	+5.6%

[24] See Appendix F of Connectivity Expert Panel Final Report. Northern Basin Connectivity Program | NSW Government Water

[25] Western Regional Water Strategy - hydrologic analysis of options Western Regional Water Strategy engagement | NSW Government Water

Base case diversions by licence category

To provide further context on the relative volumes of diversions under different licence categories, the long-term average diversions under each category of licence is shown for each valley in Table 6– noting that this updated modelling includes an additional three years of climate data that was not available for use in the previous modelling for the Western Regional Water Strategy.

Table 6. Long-term average diversions (1895-2023) by licence category for each valley under the base case in the latest approved models used in the modelling for this report

Licence category	Border Rivers GL/y	Gwydir GL/y	Namoi GL/y	Macquarie GL/y	Barwon-Darling GL/y
General security	93.2	210.0	134.3	237.4	-
Supplementary or A/B/C Class	70.7	93.3	36.3	13.5	139.2
High security	0.0	11.3	2.4	9.7	-
Local water utility	0.6	-	-	13.3	-
Stock & domestic	-	-	1.5	2.1	-
Floodplain harvesting	49.7	131.5	78.1	54.2	32.2
Total	214.2	446.2	252.6	330.2	171.3

4 Extended resumption of flows

The Panel recommended that the current resumption of flow rules be extended into the northern Basin tributaries to provide for a small flushing flow following an extend dry period all the way to Menindee Lakes prior to allowing extraction.

4.1 Panel's objective and proposed approach

There is currently a resumption of flow rule in the Barwon-Darling Water Sharing Plan[26], which protects the 'first flush' of water that comes through the system after a long dry period. This first flush is essential to reconnect disconnected reaches throughout the system, mediate declining water quality and provide the hydrological settings (wetted river channel) that will allow further pulses to pass through the system. The existing rule does not protect the first flows in tributaries from extraction.

The Panel proposed that this resumption of flow rule should be extended into the northern tributaries to protect a small fresh all the way through the system down to Menindee Lakes. The Panel proposed that the resumption of flow would be achieved by restricting access to supplementary, floodplain harvesting, Barwon-Darling and unregulated licences until lifting triggers at downstream Barwon-Darling locations are forecast to be met.

The Panel's duration for when the access restriction targets apply was based on the initial position that once Wilcannia has gone 90 days or greater with flows below baseflow, then a first flush is necessary to 'restart' the system. The durations for the other locations are based on the Panel's analysis of the equivalent period below baseflow at those locations. The Panel's proposed lifting target is the forecast achievement of small fresh for 14 days.

The Panel's proposed restriction and lifting targets are different to the existing targets in the Barwon-Darling Water Sharing Plan (Table 7). In raising the lifting targets to a small fresh flow level, the Panel has proposed removing the existing 30 GL cumulative flow trigger at Bourke.

The Panel has also proposed including 3 additional trigger locations at Mungindi, Collarenebri and Louth. These are in addition to the existing trigger locations at Walgett, Brewarrina, Bourke and Wilcannia.

Consistent with the current resumption of flow rules, the Panel proposed that restrictions could be lifted when downstream lifting targets are forecast to be met.

[26] S.50 resumption of flows in Water Sharing Plan for the Unregulated Barwon-Darling (2012). Unregulated Water Barwon, Darling and West region | NSW Government Water

Table 7. Panel's proposed restriction and lifting targets and trigger locations for the extended resumption of flow rule, compared with the targets and trigger locations included in the existing resumption of flow rule in the Barwon-Darling water sharing plan.

Location	Panel proposed restriction target (forecast)	Barwon-Darling WSP restriction target	Panel proposed lifting target (forecast)	Barwon-Darling WSP lifting target (forecast)
Mungindi (416001)	<160 ML/d for 90 consecutive days	N/A	540 ML/d for 14 consecutive days	N/A
Collarenebri (422003)	<280 ML/d for 90 consecutive days	N/A	650 ML/d for 14 consecutive days	N/A
Walgett –Dangar Bridge (422001)	<320 ML/d for 90 consecutive days	<326 ML/day for 150 consecutive days	700 ML/d for 14 consecutive days	>706 ML/d for 10 cons days
Brewarrina (422002)	<550 ML/d for 90 consecutive days	< 468 ML/day for 150 consecutive days	1,000 ML/d for 14 consecutive days	> 1,008 ML/d for 10 consecutive days
Bourke (425003)	<500 ML/d for 90 consecutive days	< 450 ML/day for 120 consecutive days	1,550 ML/d for 14 consecutive days	> 972 ML/d for 10 consecutive days or 30 GL past Bourke
Louth (425004)	<450 ML/d for 90 consecutive days	N/A	1,500 ML/d for 14 consecutive days	N/A
Wilcannia (425008)	<350 ML/d for 90 consecutive days	< 200 ML/day for 90 consecutive days	1,400 ML/d for 14 consecutive days	> 400 ML/d for 10 consecutive days

4.2 Scenario description – what was modelled

For this scenario, two approaches were modelled, with each including the following changes to the existing Barwon-Darling Water Sharing Plan resumption of flow rule as proposed by the Panel:

- flow rates for imposing restrictions have been set at below baseflow for 90 consecutive days at trigger sites,
- flow rates for lifting restrictions have been set at the lower small fresh threshold for restriction trigger sites,
- flow rates must exceed the small fresh threshold for 14 days at restriction trigger sites for lifting restrictions,
- supplementary and floodplain harvesting has been restricted in the regulated NSW Border Rivers, Gwydir, Namoi, and Macquarie River systems when the closest downstream river section in the Barwon-Darling is restricted, and

- the 30 GL cumulative flow trigger at Bourke for lifting restrictions has been removed.

Approaches have been modelled, with and without the inclusion of the additional trigger locations proposed by the Panel (Figure 4). This was done to assess if the additional trigger locations changed the distribution of impacts between the valleys. It is important to note that the environmental and economic assessments have only been completed for the extended resumption of flow approach that uses the additional trigger locations proposed by the Panel. This was because the Barwon-Darling flow targets for imposing and lifting upstream access restrictions in did not change between the two approaches.

The approaches modelled are:

- **extended resumption of flow** uses the three new trigger sites at Mungindi, Collarenebri, and Louth as proposed by the Panel in addition to the trigger locations specified in the Barwon-Darling water sharing plan (Walgett, Brewarrina, Bourke, Wilcannia). This approach is referred to as extended resumption of flow throughout this report and associated reports.
- **extended resumption of flow – existing sites** does not include the three new trigger sites, and uses the sites specified in the existing resumption of flow rule. This approach tests the outcomes of the existing trigger sites in the Barwon-Darling water sharing plan, which include a common trigger site at Walgett for the NSW Border Rivers, Gwydir and Namoi regulated river systems. These are the trigger locations that were used for the initial modelling of this rule done for the Panel to inform their final report.

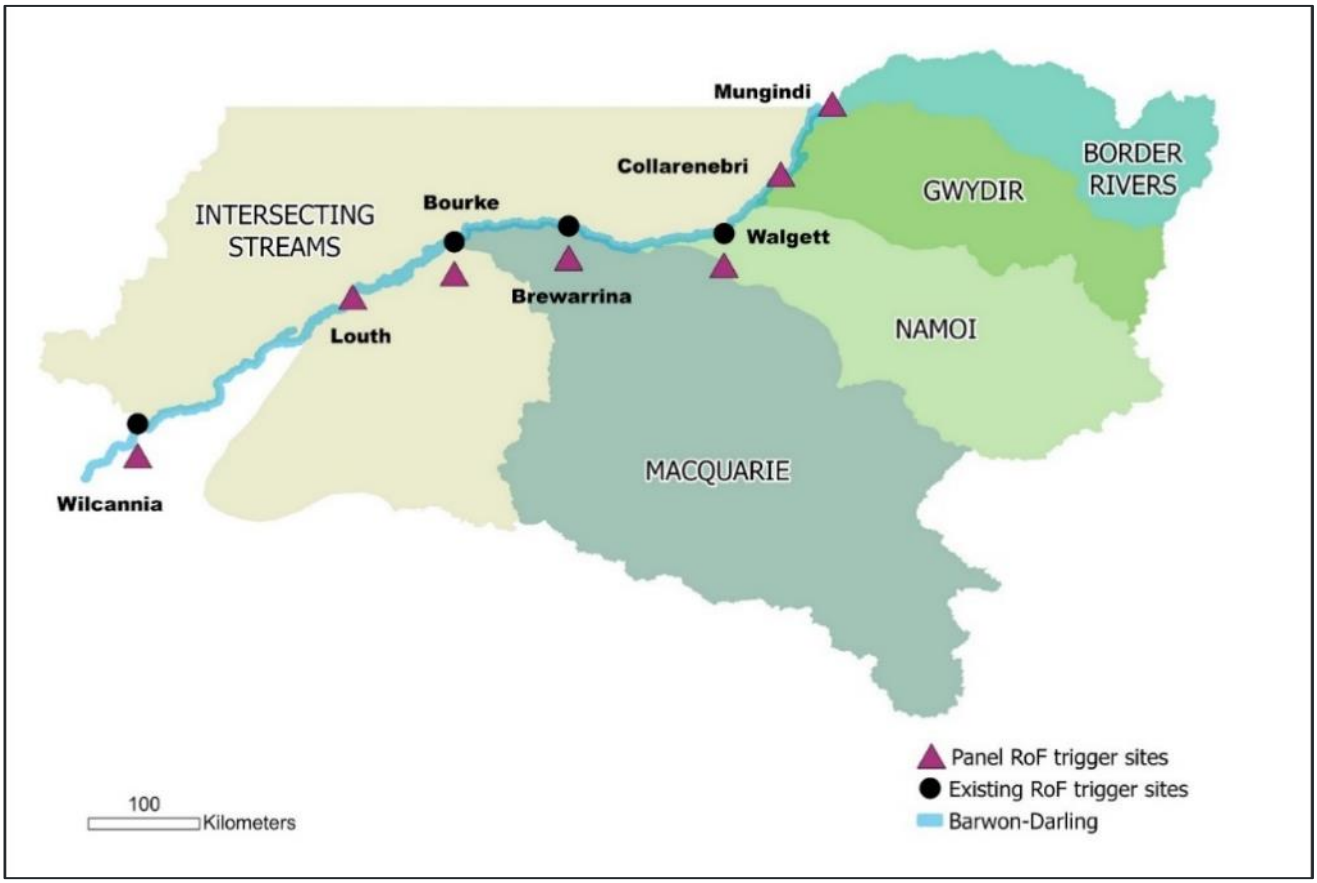

Figure 4. Extended resumption of flow trigger sites proposed by the Panel and the existing trigger sites in the Barwon-Darling water sharing plan

4.2.1 Model configuration, assumptions and limitations

The current Barwon-Darling IQQM representation of the resumption of flow rule includes restrictions to A, B, and C Class licences, but does not include restrictions to floodplain harvesting. To apply restrictions to floodplain harvesting, the existing model representation of restrictions originally used for 'embargo' periods when Menindee Lakes storage volumes were very low has been used. This allows periods of restriction for floodplain harvesting across the whole valley to be specified, but they cannot be specified by reach.

The effect of this model simplification is that all reaches of the Barwon-Darling River have restrictions commence when the first reaches commence restrictions under the resumption of flow rules, which can over-state the impact of the proposed rule. However, when the first reaches enter restrictions, the other reaches typically already have low flows occurring at these times, and the overall effect of this model simplification is expected to be small.

The proposed changes to the resumption of flow rule operation were implemented first in the Barwon-Darling River system model by adjusting the existing model parameters to reflect the recommendations of the Panel listed in Table 7, including removing the 30 GL cumulative trigger at Bourke for lifting restrictions.

Using the periods of restriction from this first model run, restrictions to supplementary access and floodplain harvesting in the regulated NSW Border Rivers (excluding Queensland water users), Gwydir, Namoi, and Macquarie River systems have been implemented using the restriction periods in the closest downstream Barwon-Darling section by:

- raising supplementary flow thresholds to a level that prevented any access, and
- using a new feature added to the model that prevents floodplain harvesting by reference to a time series that specifies the periods of restriction.

The flow inputs to the Barwon-Darling model were then revised to use the end of system flows produced by the tributary models, and the Barwon-Darling model was then a run for a second time.

Using the periods of restriction from this second Barwon-Darling model run, the periods of restrictions to supplementary access and floodplain harvesting in the upstream tributary models were updated, and these models were run a second time.

The flow inputs to the Barwon-Darling model were then revised using the results of the second run of the upstream tributary models, and the Barwon-Darling model run a third time. The periods of restriction produced by the third run of the Barwon-Darling model were then compared to those from the second run, and it was found that the changes were small, and no further iterations of model runs were undertaken.

For more information on model assumptions and limitations, see section 2.

4.3 Modelling results

For all following results, the modelling period has been extended to include the years 1895 – 2023.

4.3.1 Long term average diversions

The modelling results in Table 8 and Table 9 show that long-term average annual diversions are reduced across all valleys due to the increase in flow rates and duration of those flows before lifting the resumption of flow rule restrictions to supplementary and floodplain harvesting access in the regulated rivers, and Class A, B, and C restrictions in the Barwon-Darling River. These impacts vary across the valleys in response to the variation in flow rates and timing along each of the rivers.

The impact to long-term average annual diversions of the extended resumption of flow rule is higher than modelled for the Panel[27] due to the increase in the period that flows must exceed small fresh thresholds before lifting restrictions, with the suspension of the 30 GL cumulative flow trigger at Bourke for lifting restrictions. The largest change is for the Namoi valley, where the model has been recalibrated.

The interaction between the different flow thresholds and hydrology at each site produces variations in the periods of restriction in the Border Rivers and Gwydir for the two approaches assessed. This changes the level of impacts in the Border Rivers and Gwydir under each approach.

For the extended resumption of flow rule, the Panel's new trigger site at Collarenebri produces more days of restriction than the site at Walgett, which was used to determine periods of restriction in the Gwydir valley in previous modelling. This is increasing the impacts to supplementary access and floodplain harvesting in the Gwydir valley compared to the existing Walgett trigger location.

Compared to the base case, Gwydir diversions change by 5.7% under the extended resumption of flow using Panel trigger locations (Table 8) and 3.1% under extended resumption of flow using existing trigger locations (Table 9). Conversely, the new trigger site at Mungindi produces fewer restriction days, than the site at Walgett, and the impacts to diversions in the Border Rivers has been reduced. Compared to the base case, Border Rivers diversions change by 3.4% under the extended resumption of flow using Panel trigger locations (Table 8) and 4.8% under the extend resumption of flow using the existing Barwon-Darling water sharing plan trigger locations (Table 9).

Walgett is used as the trigger location for the Namoi valley in both approaches. This means that there is no difference in the Namoi diversion changes between the approaches (Table 8 and Table 9).

[27] See Appendix F of Connectivity Expert Panel Final Report. Northern Basin Connectivity Program | NSW Government Water

Table 8. Extended resumption of flow – Panel trigger sites: change in long-term average annual diversions (1895-2023), including absolute change (GL/y) and relative change (%) from the base case.

Valley	Base case	Extended RoF	Absolute change	Relative change
	GL/y	GL/y	GL/y	%
Border Rivers	214.2	207.0	-7.2	-3.4%
Gwydir	446.2	420.8	-25.4	-5.7%
Namoi	252.6	239.3	-13.3	-5.3%
Macquarie	330.2	327.2	-3.0	-0.9%
Barwon-Darling	171.3	164.9	-6.4	-3.7%

Table 9. Extended resumption of flow rule – existing trigger sites: change in long-term average annual diversions (1895-2023), including absolute change (GL/y) and relative change (%) from the base case.

Valley	Base case	Extended RoF – existing sites	Absolute change	Relative change
	GL/y	GL/y	GL/y	%
Border Rivers	214.2	203.9	-10.3	-4.8%
Gwydir	446.2	432.2	-13.9	-3.1%
Namoi	252.6	239.3	-13.3	-5.3%
Macquarie	330.2	327.1	-3.1	-0.9%
Barwon-Darling	171.3	166.1	-5.2	-3.0%

The changes in long term average diversions for each licence category are presented in Table 10 which shows that supplementary water use is most impacted, followed by floodplain harvesting. There is a slight increase in general security use as irrigators more highly utilise their general security accounts.

Table 10. Extended resumption of flow – Panel trigger sites: change in long-term average annual diversions for each licence category (1895-2023), including absolute change (GL/y) and relative change (%) from the base case.

Valley	General security		Supp. or class A/B/C*		Floodplain harvesting	
	GL/y	%	GL/y	%	GL/y	%
Border Rivers	+2.8	+3.0%	-7.3	-10.4%	-2.6	-5.3%
Gwydir	+1.4	+0.7%	-18.7	-20.0%	-8.1	-6.2%
Namoi	+1.0	+0.8%	-6.0	-16.4%	-8.4	-10.8%
Macquarie	+0.8	+0.3%	-1.9	-14.1%	-1.9	-3.5%
Barwon-Darling			-4.3	-3.1%	-2.1	-6.4%

* Supplementary (supp.) access occurs in the Border Rivers, Gwydir, Namoi and Macquarie valleys. Class A/B/C access occurs in the Barwon-Darling.

Table 11. Extended resumption of flow - existing sites: change in long-term average annual diversions for each licence category (1895-2023), including absolute change (GL/y) and relative change (%) from the base case.

Valley	General security		Supp. or class A/B/C*		Floodplain harvesting	
	GL/y	%	GL/y	%	GL/y	%
Border Rivers	+3.5	+3.7%	-10.4	-14.7%	-3.3	-6.7%
Gwydir	+0.9	+0.4%	-11.3	-12.1%	-3.5	-2.7%
Namoi	+1.0	+0.8%	-6.0	-16.4%	-8.4	-10.8%
Macquarie	+0.7	+0.3%	-1.9	-14.1%	-1.9	-3.5%
Barwon-Darling	-	-	-3.5	-2.5%	-1.7	-5.5%

* Supplementary (supp.) access occurs in the Border Rivers, Gwydir, Namoi and Macquarie valleys. Class A/B/C access occurs in the Barwon-Darling.

4.3.2 Annual diversions

The impacts on water users varies across years, often with many years of little impacts and a few years with more significant impacts. To show the variability of impacts across all years of the model run, the annual diversions for each valley under the extended resumption of flow are shown from Figure 5 to Figure 9 with the base case diversions and the changes to these that are modelled in this scenario. Figures for the extended resumption of flow rule – existing sites are from Figure 10 to Figure 14.

The figures show that there can be some years where diversions increase. Often, this is due to the modelling of restrictions in one supplementary access period resulting in lower on-farm storage volumes that can take more water than previously in a subsequent supplementary access period where the restrictions did not apply.

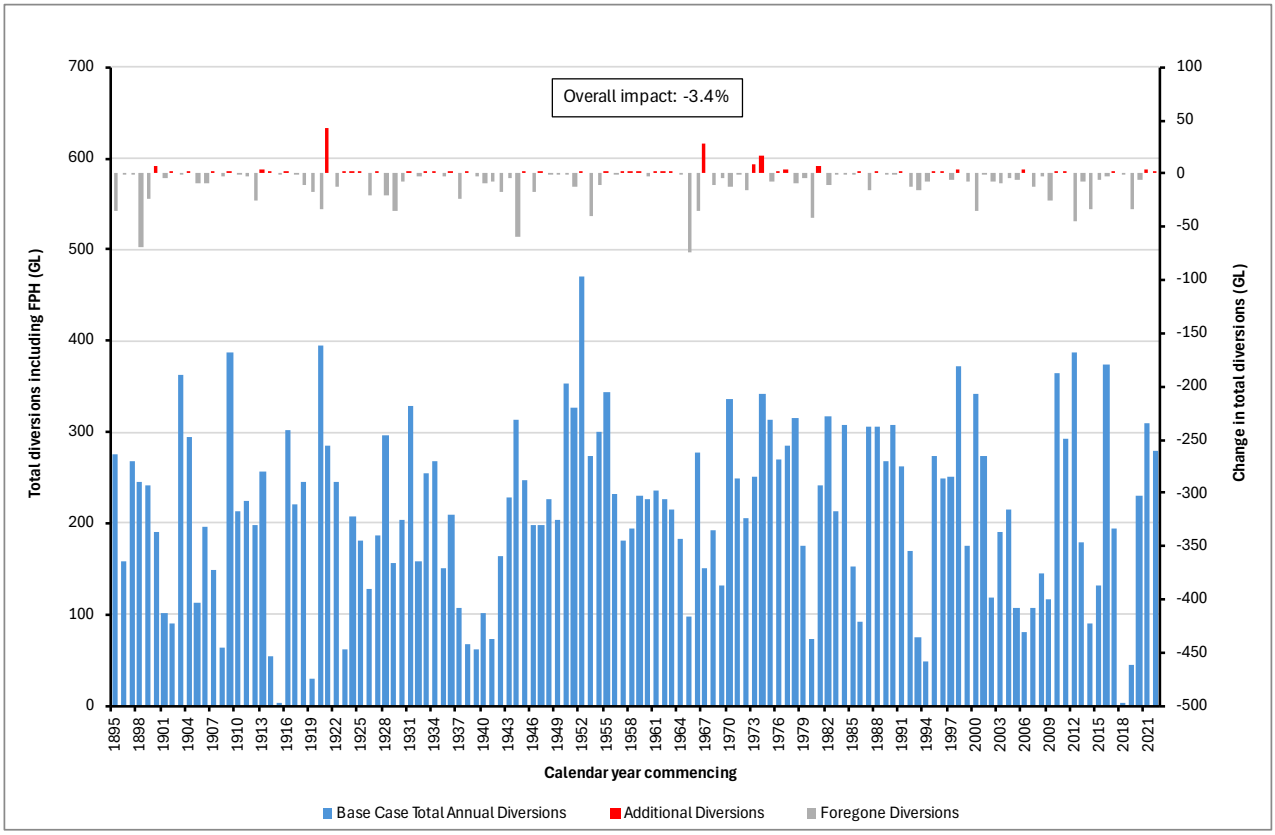

Figure 5. NSW Border Rivers annual base case diversions and changes arising from the extended resumption of flow rule – panel trigger (1895 – 2023)

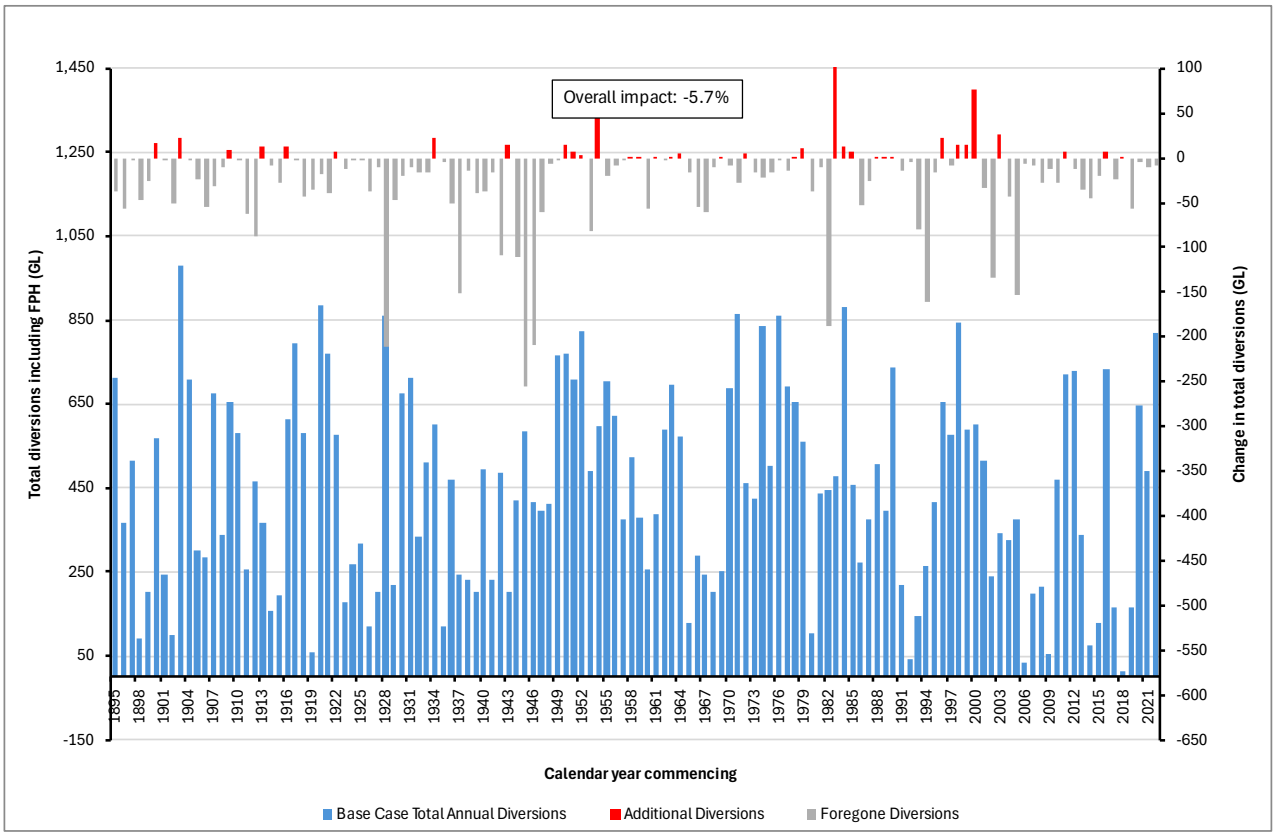

Figure 6. Gwydir annual base case diversions and changes arising from the extended resumption of flow rule – panel trigger sites (1895 – 2023)

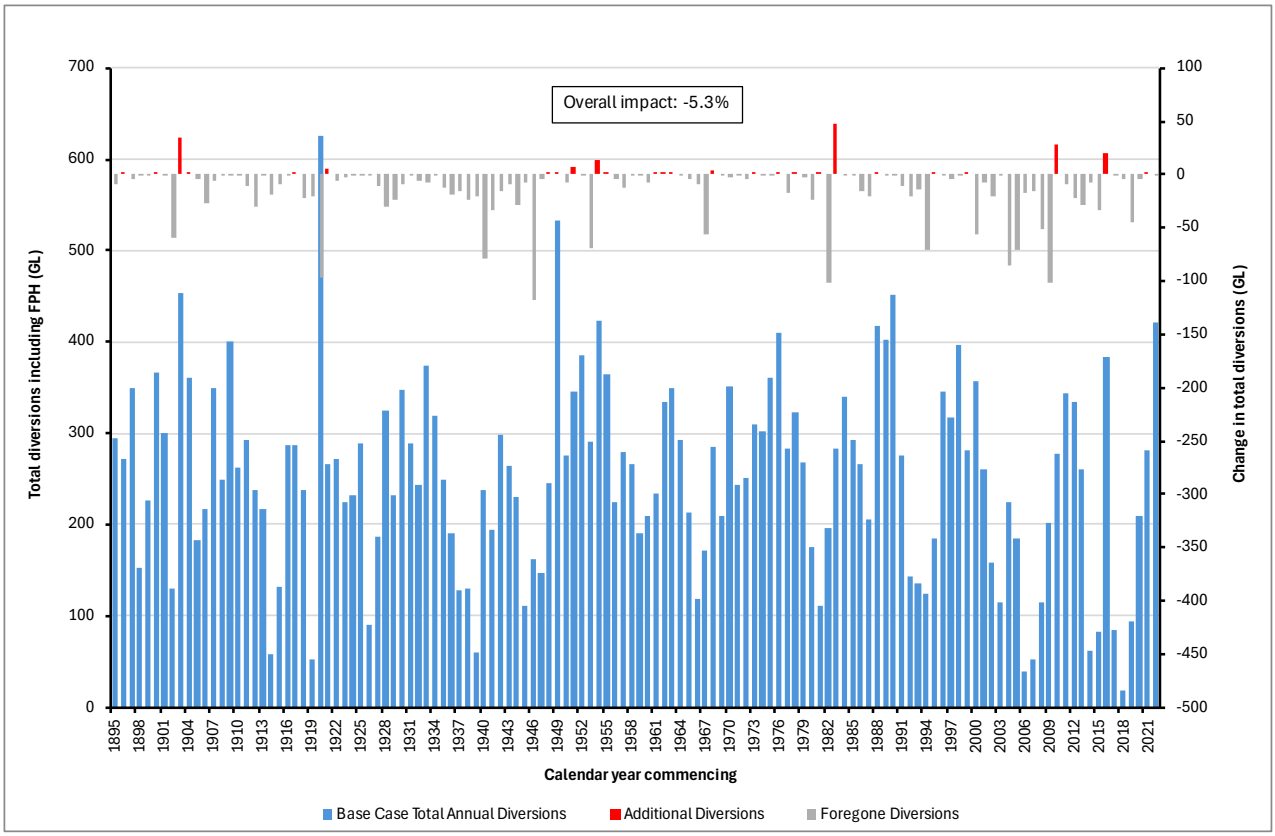

Figure 7. Namoi annual base case diversions and changes arising from the extended resumption of flow rule – panel trigger sites (1895 – 2023)

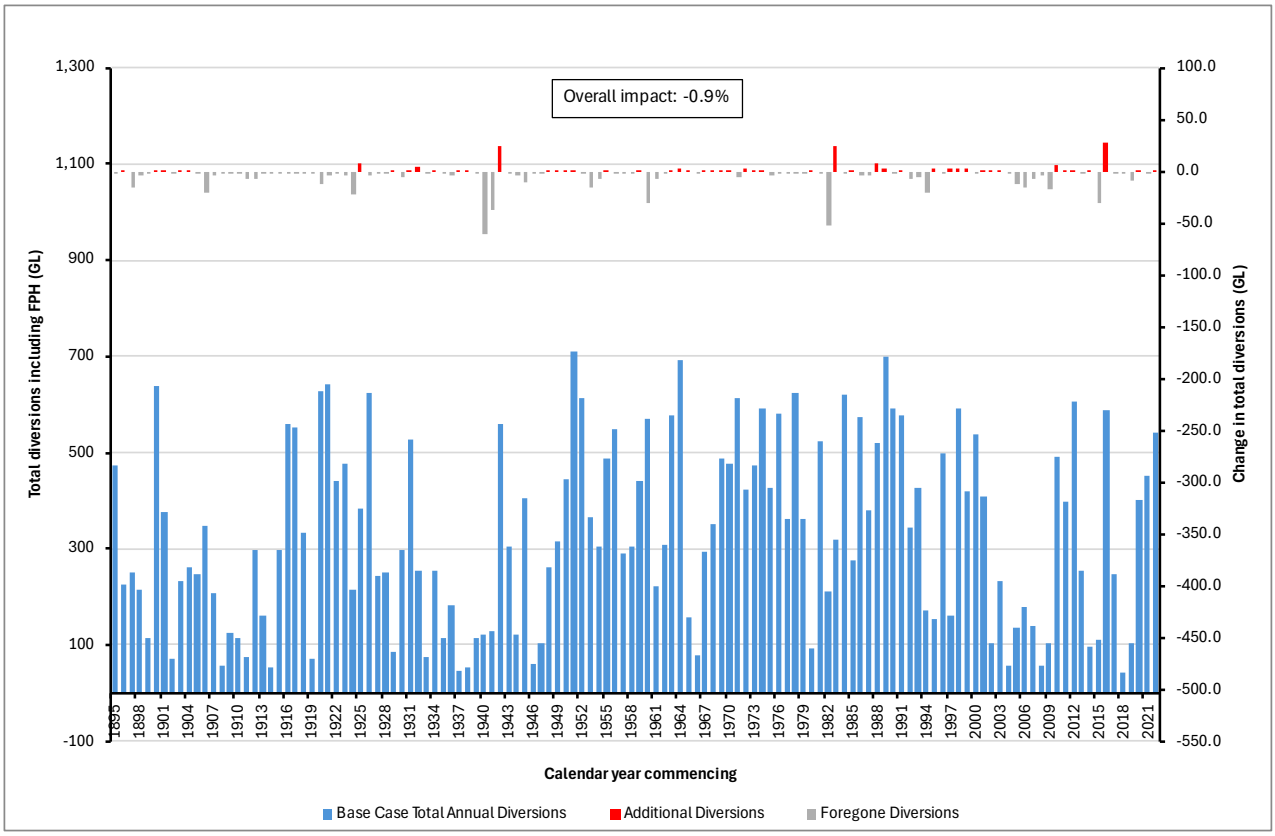

Figure 8. Macquarie annual base case diversions and changes arising from the extended resumption of flow rule – panel trigger sites (1895 – 2023)

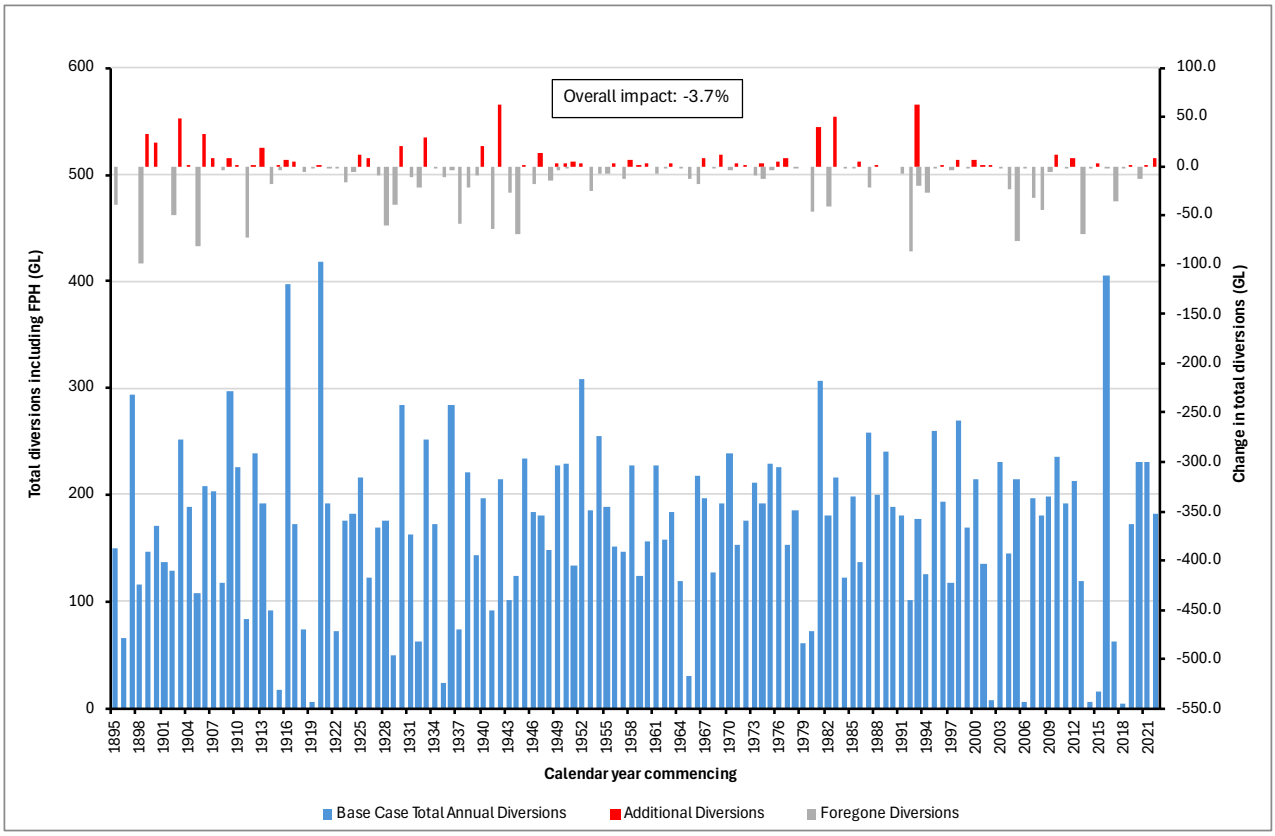

Figure 9. Barwon-Darling annual base case diversions and changes arising from the extended resumption of flow rule – panel trigger sites (1895 – 2023)

Extended resumption of flow rule using existing Barwon-Darling WSP trigger sites

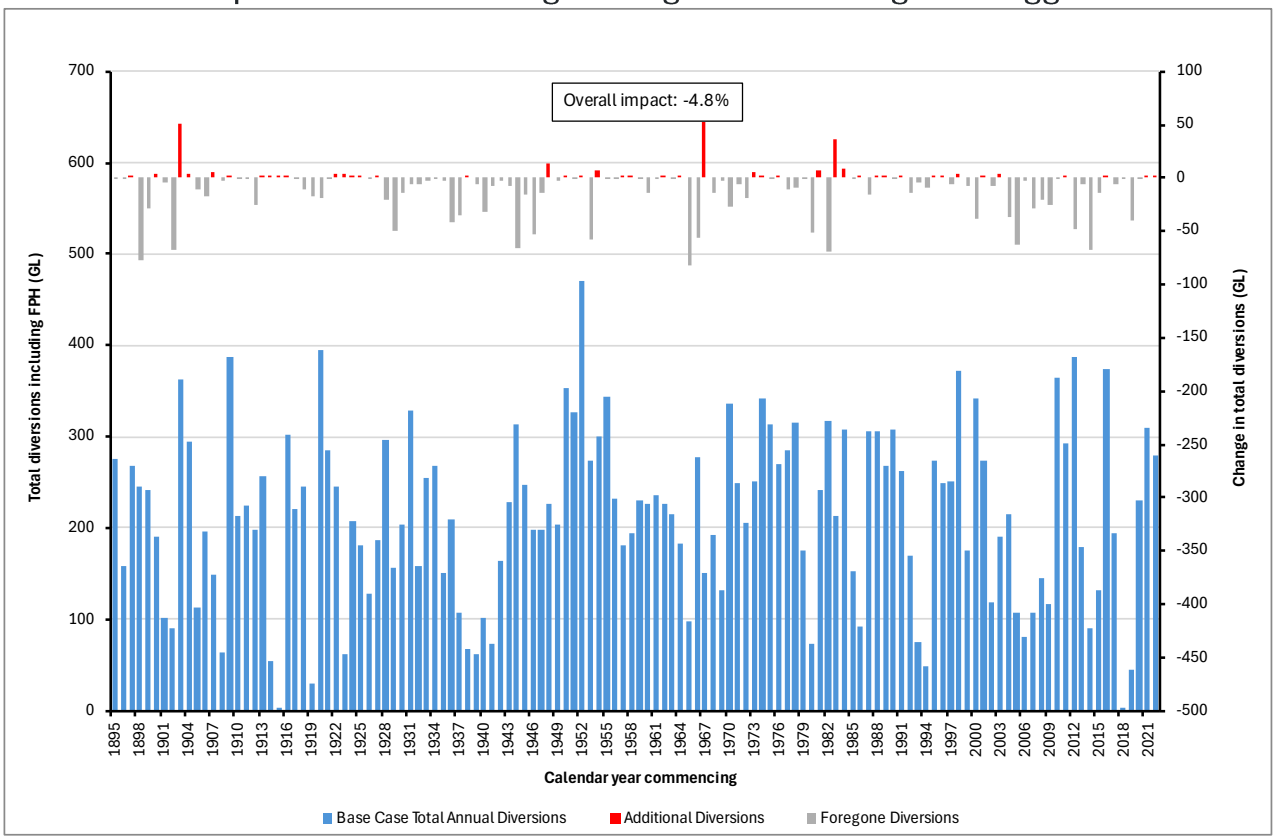

Figure 10. NSW Border Rivers annual base case diversions and changes arising from the extended resumption of flow rule using existing Barwon-Darling WSP trigger sites (1895 – 2023)

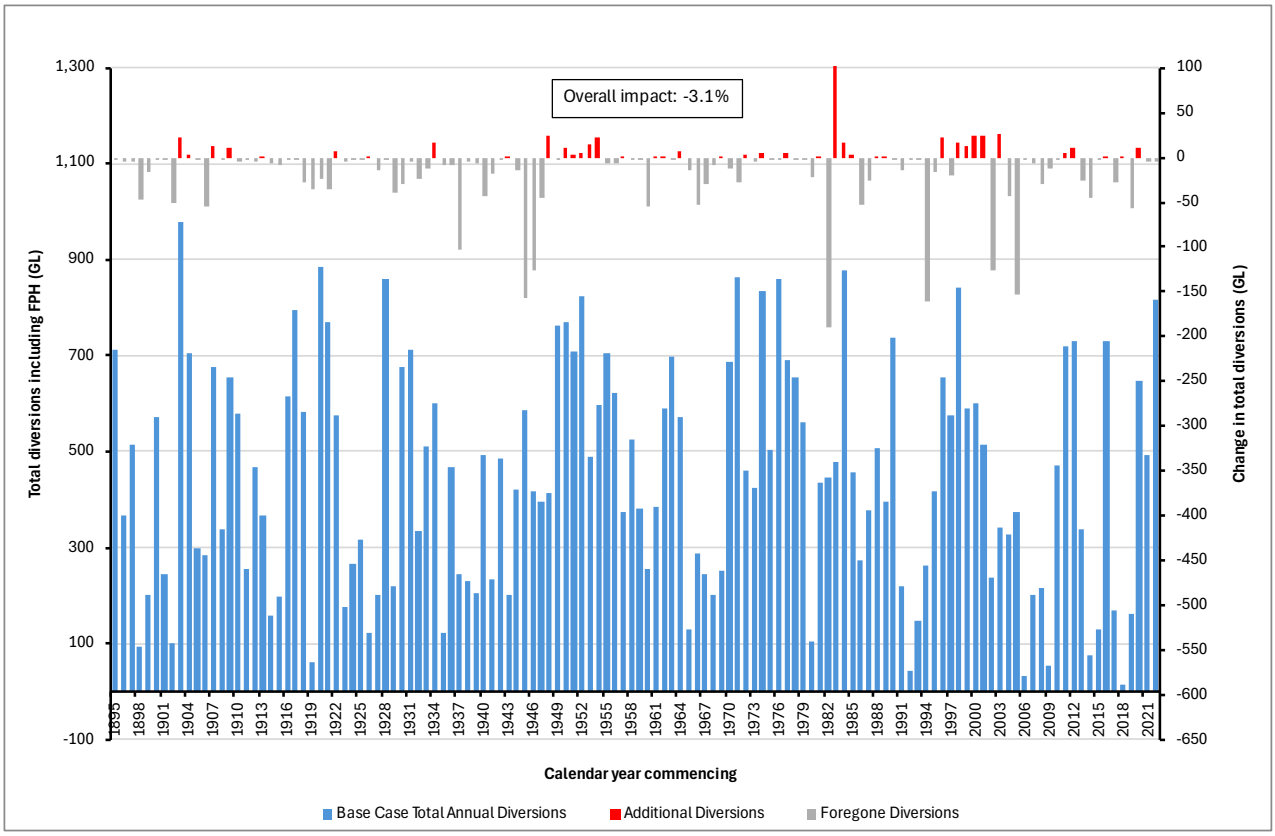

Figure 11. Gwydir annual base case diversions and changes arising from the extended resumption of flow rule using existing Barwon-Darling WSP trigger sites (1895 – 2023)

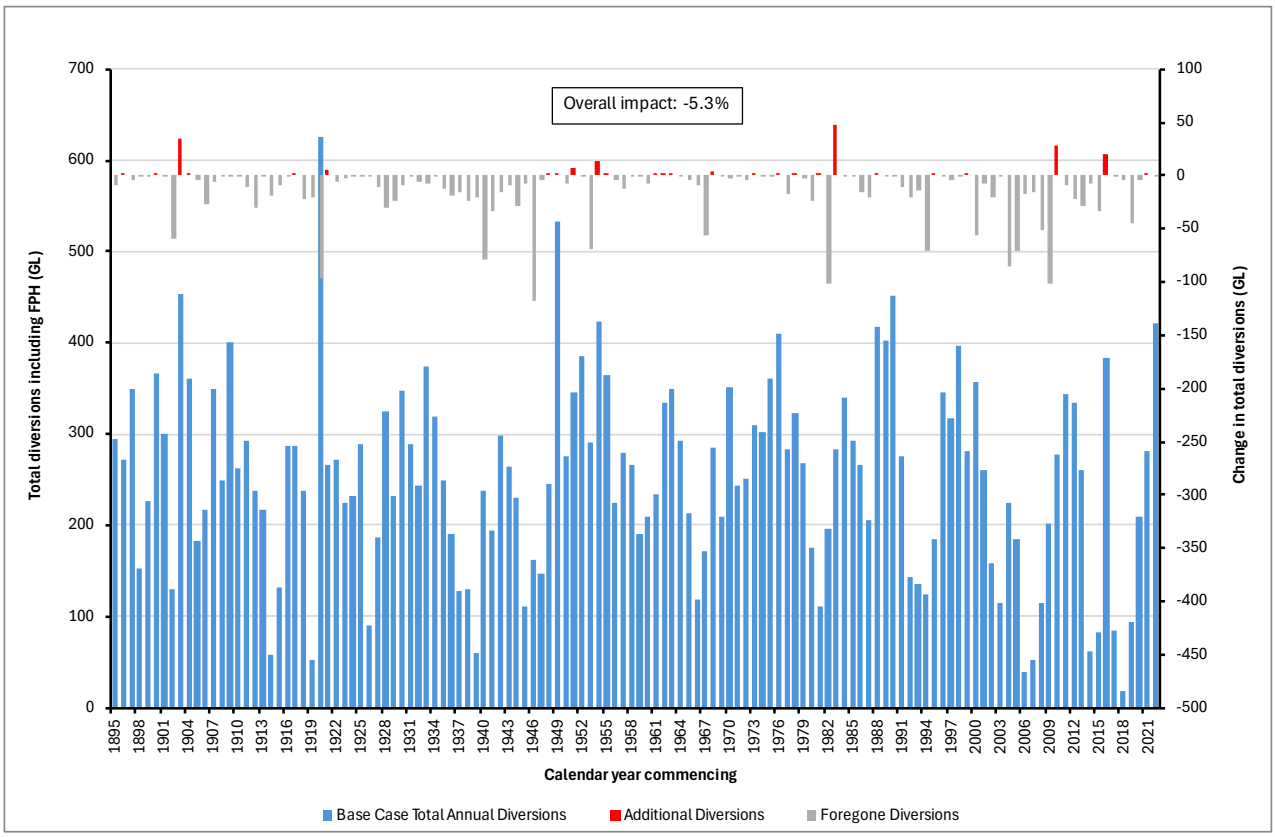

Figure 12. Namoi annual base case diversions and changes arising from the extended resumption of flow using existing Barwon-Darling WSP trigger sites (1895 – 2023)

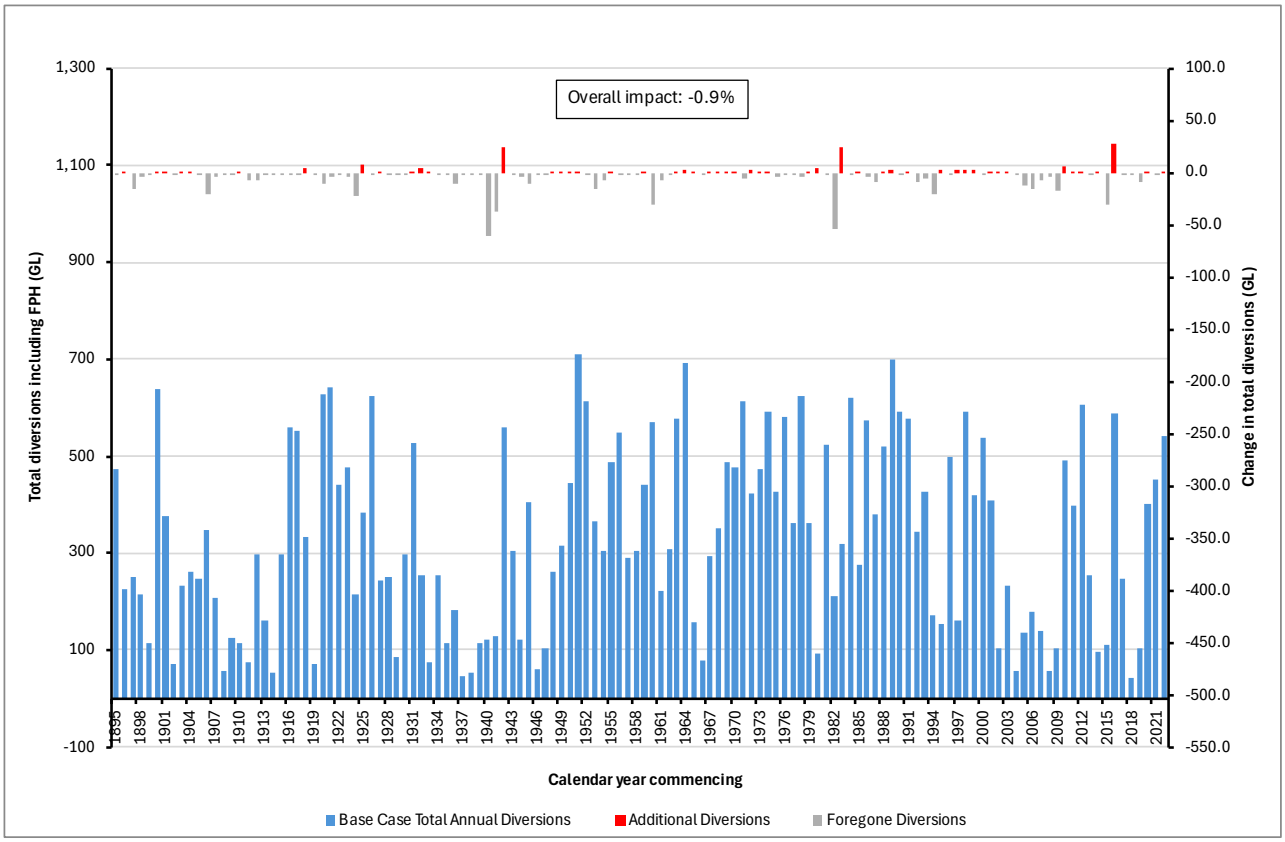

Figure 13. Macquarie annual base case diversions and changes arising from the extended resumption of flow using existing Barwon-Darling WSP trigger sites (1895 – 2023)

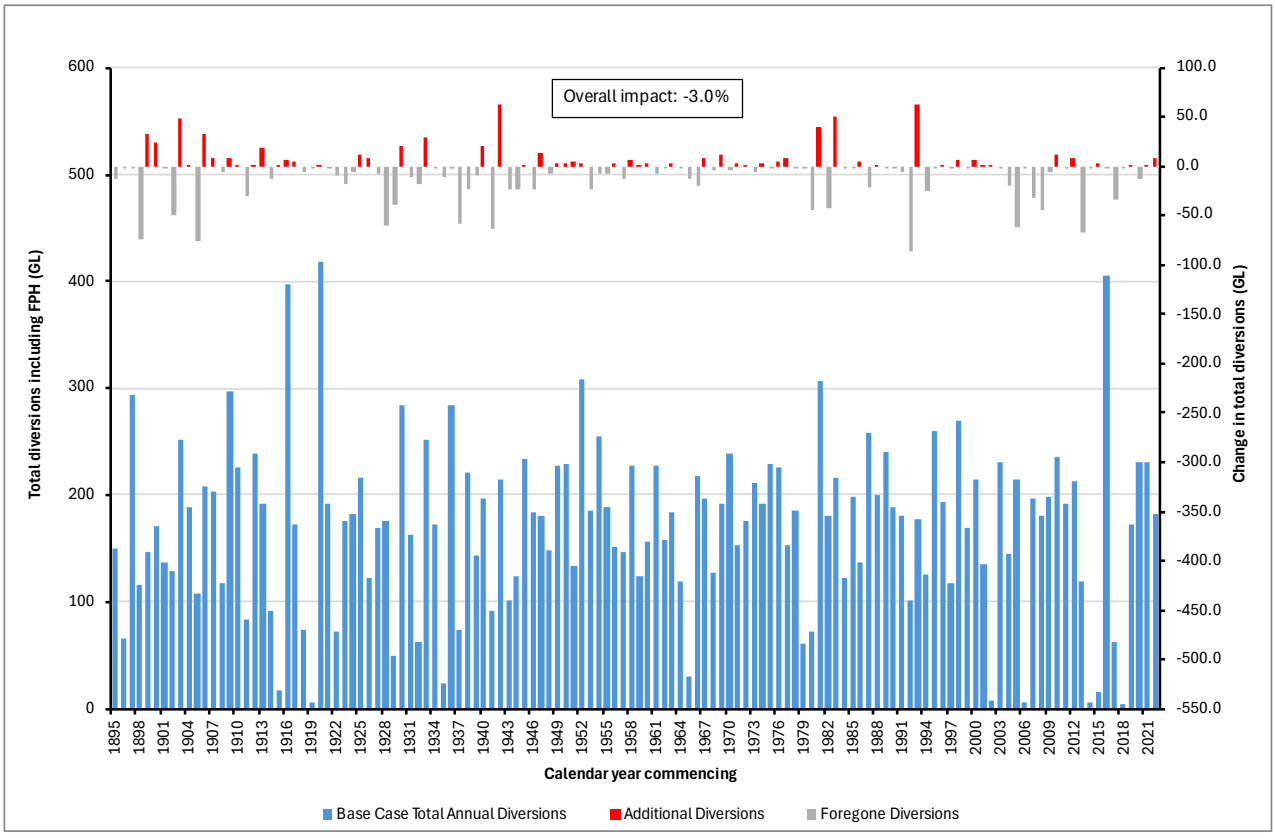

Figure 14. Barwon-Darling annual base case diversions and changes arising from the extended resumption of flow rule using existing Barwon-Darling WSP trigger sites (1895 – 2023)

5 End of system flow targets

The Panel recommended that regulated water sharing plans should have an end of system flow requirement to enable baseflow targets in the Barwon-Darling to be achieved during non-dry times.

5.1 Panel's objective and proposed approach

The Panel recommended that an end of system minimum flow rule should be added to the Gwydir, Namoi and Border Rivers regulated water sharing plans to achieve baseflows in the Barwon-Darling during non-dry times[28]. The proposed flow target was equivalent to the bottom of the baseflow environmental watering requirement in the relevant long-term water plan (Table 12). The targets were designed to achieve baseflows in the Barwon-Darling (Table 13).

The Panel recommended that the end of system flow target should be achieved through limitations on supplementary and floodplain harvesting access in the first instance, with releases made from storage if these flows are not adequate.

The Panel recommended that dam releases to support end of system flow targets are suspended when the system enters a dry stage. The trigger the Panel's proposed for transition dry stage rules in a valley, was inflows to the major dams falling below the 75th percentile on average over a 30-day period. The Panel based the selection of the trigger on analysis of historic inflows to the dams and a general principle that when inflows to the dams are no longer supporting the end of system flow, then releases should be suspended.

The panel recommended that the department consider further sensitivity analysis to maximise achievement of the targeted outcomes while minimising impact.

The Panel's proposed end of system flow targets are shown in Table 12 and have been designed to achieve baseflows in the Barwon-Darling during non-dry times as identified in Table 13.

[28] The Panel has not included a recommendation for an end of system flow rule for the Macquarie-Cudgegong as the end of system flows discharge into the Macquarie Marshes. Modelling indicated that implementing a similar end of system flow rule as other valleys did not provide a downstream benefit. The Panel has considered potential rules in the unregulated systems between the Macquarie Marshes and the Barwon-Darling that may help contribute to connectivity.

Table 12 Panel's proposed end of system targets to meet baseflows in the Barwon-Darling River. The reference river gauges are given in brackets.

Location	Baseflow target*
Border Rivers (gauge 416001 - Barwon River at Mungindi)	160 ML/d
Namoi (gauge 419091 - Namoi River at U/S Walgett)	30 ML/d
Gwydir (gauge 418055- Mehi Near Collarenebri)	40 ML/d
Gwydir (gauge 416052 - Gil Gil Creek at Galloway)	25 ML/d

*Based on the bottom of baseflow environmental water requirements in the relevant long-term water plan[29]

Table 13: Panel proposed baseflow targets in the Barwon-Darling River. The reference river gauges are given in brackets.

Location	Baseflow target*
Mungindi (gauge 416001 - Barwon River at Mungindi)	160 ML/d
Collarenebri (gauge 422003 – Barwon River at Collarenebri)	280 ML/d
Walgett (gauge 422001 – Barwon River at Dangar Bridge)	320 ML/d
Bourke (gauge 425003 – Darling River at Bourke Town)	500 ML/d
Wilcannia (gauge 425008 – Darling River at Wilcannia main channel)	350 ML/d

*Based on the bottom of baseflow environmental water requirements from the Barwon-Darling Long Term Water Plan102F[30]

Panel recommendations on protection of small and large freshes

The Panel recommended that water sharing plans should include restrictions on supplementary, floodplain harvesting, and A, B and C class licences in the Barwon-Darling to support a 14-day minimum small fresh between September to April each year and a 15-day minimum large fresh every 2 years, anytime, but ideally July to September. The Panel's proposed small fresh and large fresh flow targets are included in Appendix A.

It should be noted that the department has not modelled any potential rules specifically focussed on protecting small and large freshes during non-dry times. The initial focus has been on modelling approaches to achieving the resumption of flow, end of system targets and connectivity environmental water allowance proposals. We have assessed how they are changing the achievement of small and large freshes. Consideration will be given in the next phase to the need for investigating additional rules.

[29] NSW Government, (2022), *NSW Border Rivers Long Term Water Plan Parts A and B*; NSW Government, (2020) *Namoi Long-Term Water Plan Part B: Namoi planning units*; NSW Government(2020) *Gwydir Long-Term Water Plan Part B: Gwydir planning units*

[30] NSW Government (2020) *Barwon-Darling Long-Term Water Plan Part B: Barwon-Darling planning units*

5.2 Scenario description – what was modelled

The Panel recommended that the end of system flow target should be achieved through limitations on supplementary and floodplain harvesting access in the first instance, with releases made from storage if these flows are not adequate. This acknowledges that restrictions to supplementary and floodplain harvesting alone would not be sufficient to meet end of system flow targets in non-dry times. The Panel recommended that the department conduct analysis to determine how dam releases could be used to ensure the end of system flow targets could be achieved while minimising impacts on diversions.

As water sharing plans already contain restrictions to supplementary access that largely provide for the recommended end of system targets to be met, no additional restrictions were modelled for this analysis. No restrictions were modelled for floodplain harvesting either, as we don't understand the return flow volumes and can only place a blanket restriction on floodplain harvesting access whenever the model is ordering water for the end of system flows. The area of return flows is one that the department continues to work on when the resources are available. There are existing end of system flow rules in the Border Rivers[31] and Namoi[32] water sharing plans. These existing targets are included in the models.

The department has modelled two different approaches for making dam releases to support achievement of the end of system flow target in non-dry times in the regulated Border Rivers, Gwydir and Namoi valleys. This was done to investigate the difference in benefits and impacts of each approach.

The approaches assessed were:

- **End of system - translucency**: releasing a proportion of the daily inflows to the dam(s) in each valley to meet the end of system flow target, referred to as a translucent release. This approach only makes releases each day if there is sufficient inflow to the storages over the preceding 24 hours, and does not require reserves to be set aside, representing an approach that improves baseflows with potentially lower impacts to water users.
- **End of system – high security accounts:** a high security account has been created in each of the NSW Border Rivers, Gwydir, and Namoi River system models, which was used to supply water to meet the recommended end of system flow targets. This approach makes releases whenever required, and has reserves set aside, representing an approach that can achieve baseflow targets with more certainty, although with higher impacts to water users.

For both approaches, releases were not made in periods where the rolling 30-day average dam inflows fell below the 75th percentile (the dry inflow trigger). To calculate the dry trigger, the average daily inflows to the dams for each month were ranked from largest to smallest for a valley, the inflow that is exceeded 75% of the time is referred to as the 75th percentile. Where a valley has two dams, the inflows to both dams were added together each day.

[31] S45 (4c) and S47 Water Sharing Plan for the NSW Border Rivers Regulated River Water Source 2021 Border Rivers region | NSW Government Water

[32] Part 3, clause 14 Water Sharing Plan for the Upper Namoi and Lower Namoi Regulated Water Source 2016. Namoi region | NSW Government Water

The calculated dry triggers for each valley were calculated for the period of modelled storage inflows (1895 – 2023). The results of the dry trigger calculation and the proposed end of system flow targets are compared in Table 14. This shows that the 75th percentile inflows to the dams is smaller than the end of system flow target for the Border Rivers, and the two are similar for the Gwydir valley. If allowance is made for transmission losses, there would be periods where these target flows are not able to be met by simply passing an appropriate portion of inflows.

Table 14. Comparison of the end of system flow targets and dry triggers for each valley

Valley	End of system target flow		Dry trigger	
	Location	Flow ML/d	Storage	Daily average inflow ML/d
NSW Border Rivers	Barwon River at Mungindi	160	Pindari + Glenlyon	54
Gwydir	Gil Gil Ck at Galloway	25	Copeton	61
	Mehi River at Collarenebri	40		
Namoi	Namoi River at Walgett	30	Split Rock + Keepit	102

Alternative approaches to achieving the end of system flow targets and improving Barwon-Darling baseflows while minimising impacts on diversions will be explored in the next phase of modelling which will occur after discussions with key stakeholders. The next phase of work will include sensitivity analysis on the trigger for suspending dam releases to meet the end of system flow target, for example dam inflows below the 65th and 85th percentiles.

It was not possible to configure the Barwon-Darling model to protect the additional inflows from take by water users. This means that both the flow benefits along the Barwon-Darling and the impacts to water users are being under-estimated.

Protection of the additional inflows using, for example, active management can be undertaken in practice, which would protect additional inflows to realise the flow benefits along the Barwon-Darling. This is something we are unable to directly model at present but could potentially estimate with further work as there is no representation of active management, or other similar arrangements.

5.2.1 Model configuration and assumptions

IQQM and Source models can be configured to have minimum flow requirements at any location. The models will increase orders to the dam each day based on the minimum flow requirement, plus any transmission losses, less any expected tributary inflows. This is a similar process in the model to that for water users.

Minimum flow requirements at the end of regulated river systems have the longest flow travel times, and the effects of downstream tributary inflows and transmission losses must be forecast, a challenge for the models and also for river operators in reality. In the northern NSW regulated river

systems there are only limited re-regulatory storages along the rivers to capture surplus flows or augment flows to meet an end of system flow target.

End of system - translucency

This scenario investigates a 'translucent' dam release (a release of some or all the inflows to the storage on a daily basis) to provide flows to meet the end of system flow targets. This has been initially trialled by setting a constant translucent release rule, that requires a set portion of the dam inflows to be released, until the dam inflows fall below the 75th percentile (dry trigger proposed by the Panel).

It is difficult within the current model configurations to identify the incremental increase in each daily order at the dams that is due to the end of system flow target, as transmission losses and tributary inflows are applied to the bulk water orders and are not separately apportioned to each order. The method used for this analysis is to approximate the long-term increase in releases required is to create a time series of required releases from the base case model results and develop a constant translucency rule that approximates these additional releases. The steps that have been undertaken to do this are summarised below:

- an analysis of the end of system flows in each tributary valley (excluding the Macquarie) was undertaken to assess when base case model flows were less than the proposed target flows
- this time-series of flows below target at the end of system in the base case was then used to create a time-series of forced orders at the dam ('forced order')
- a single translucency rule was then developed that produced a similar flow-duration curve (for the end of system flow) to the 'forced order' step above. This translucency rule was used to generate an order at the end of the system to ensure the released water was protected from water use within the model.

The end of system - translucency rules developed for each valley and applied as an order at the end of each river system are shown in Table 15. These were developed to meet the end of system targets listed in Table 12.

Table 15. Translucency rules developed for each valley meet end of system target.

Valley	Translucency release rule
Border Rivers	If Glenlyon + Pindari dam inflow <165 ML/day then order the total inflow, otherwise order 100 ML/d
Namoi	If Keepit dam inflow<30 ML/day then order the total inflow, otherwise order 12 ML/day
Gwydir (Gil Gil)	If Copeton dam inflow <65ML/day then order the total inflow, otherwise order 30ML/day
Gwydir (Near Coli)	If Copeton dam inflow <65ML/day then order the total inflow, otherwise order 30ML/day

An example of the end of system flows during the rule development process above is shown in Figure 15 as flow-duration curves for the Mehi Reiver near Collarenebri. This shows:

- a ‘perfect outcome’ where the base case flow is augmented to achieve the target baseflow up to the 75% exceedance, beyond which the dry trigger stops releases,
- the ‘forced order’ result, where the model is forced to order water only on the days when the base case scenario flows fall below the target,
- the results of the Mehi end of system - translucency release rule in Table 15, and
- the end of system flows for the end of system flow – high security accounts scenario.

The ‘forced order’ results in Figure 15 show that the model’s process of routing flows and estimating losses and downstream tributary inflows create a spread of flows at the end of the system (the orange line does not match the pink line). In reality, river operators also face many of the same issues when forecasting release requirements at the end of the river system and would not be able to achieve the ‘perfect outcome’ either.

The end of system - translucency rule results in Figure 15 vary from the forced order (orange line) due to the applications of a single release rule across the whole model run.

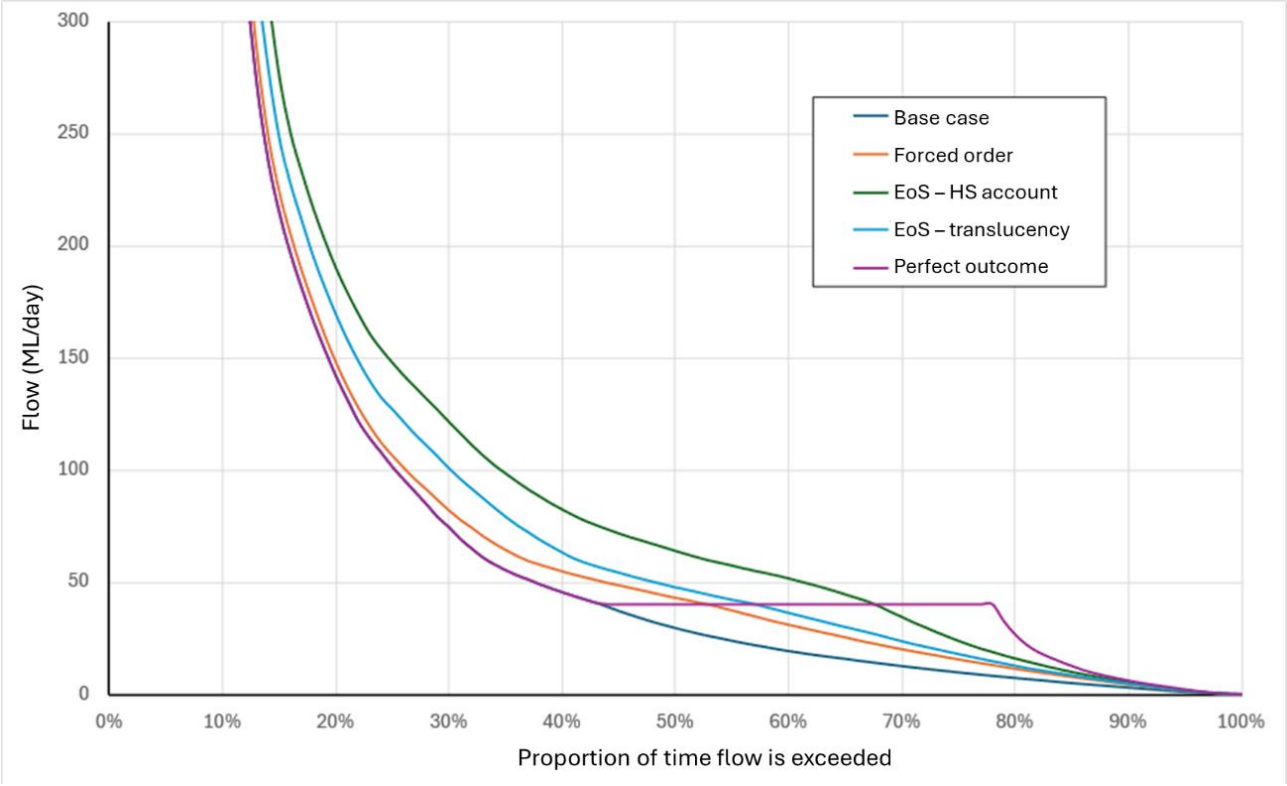

Figure 15. Flow duration curves for the Mehi River near Collarenebri under the end of system approaches

The long-term average flows for each of the modelled scenarios in Figure 15 are shown in Table 16. This indicates that the additional volume of water delivered to the end of system under the translucency rule is only slightly above that for the ‘perfect outcome’. This suggest that further refinements of the end of system - translucency rule are:

- likely to improve the proportion of time that the end of system flow targets are achieved (although not as much as using a high security account under end of system – high security accounts), and

- unlikely to significantly reduce impacts to water users, as the overall flow volume at the end of the system are already close to the 'perfect outcome'.

Table 16. Gwydir Valley long term average end of system flows

Modelled scenario	Mehi River near Collarenebri GL/y	Gil Gil Creek at Galloway GL/y
Base case	96.1	46.7
Perfect outcome	99.1	49.0
Forced Order	99.0	48.7
EoS - translucency	103.4	49.2
EoS - HS accounts	108.9	51.5

A similar distribution of results was achieved across the end of system flow points for the Border and Namoi Rivers.

Further work is required to be able to model a daily translucent release based on the incremental increase in orders, rather than a constant rule, and will be considered further in the next stage of modelling of connectivity measures. This may also be an issue to implement operationally, as it is likely to require a 'without end of system target' release to be estimated each day to then determine the increase in release required to meet the end of system target (to then ensure this is lower than the storage inflow over the previous day).

End of system - high security accounts

A high security account volume has been sized by trialling different volumes to determine the minimum required to ensure ordered replenishments could be delivered in any year, in combination with a 2-year reserve (as is used for the existing essential requirements reserve). The results are shown in Table 17.

Table 17. High security account details for end of system – high security account approach assessed.

Valley	HS end of system account size GL	2-year reserve increase GL
Border Rivers	65	208
Namoi	12	38.4
Gwydir (Gil Gil)	9.5	30.4
Gwydir (Near Coli)	14.6	46.9

Reserves are largely set based on a worst-case inflow (and transmission loss) sequence – often the lowest observed inflows. In this scenario, the reserve has been configured as a 2-year reserve based on existing practice for essential requirements (supplies for local water utilities and high security licences). However, the current practice is to ensure that essential requirements can continue to be met through the worst drought, whereas the end of system target flow does not need to be met when the 'dry inflow' trigger (storage inflows drier than 75% exceedance) – likely for significant periods during droughts. Consequently, there is an argument that the 2-year reserve may not be required.

The Border Rivers larger account and reserve sizes result from the much larger end of system flow target at Mungindi compared to the targets at the end of the Gwydir and Namoi valleys. The model has also been configured so that the high security account and reserves are only being drawn from the NSW share of resources.

Models do not perform as well in extremes of climate, and the model does not represent some processes as well during very dry periods:

- In particular, the constant flow-loss relationships used in the models have been calibrated to provide a reasonable match over long periods, and tend to under-estimate losses in dry times, which might suggest that reserves could be larger.
  - — However, as noted above, dam releases to meet the end of system target are not required for periods during droughts, and it could also be argued that the effect of higher losses during droughts may not be as significant.
- Conversely, the models do not simulate operational contingency measures such as block releases, which might suggest that reserves could be smaller.
  - — However, contingency measures may not be appropriate for the end of system flow targets or may not be relevant as end of system targets are not required for periods during droughts.

For this analysis, no investigation of additional configurations for the high security accounts to address these potential (and sometimes opposing) shortcomings has been undertaken.

The Namoi Source model restricts water orders in the lower end of the Namoi River to a maximum of 50 ML/day, which is used to manage water ordering issues for Walgett in the model (due to long travel times and attenuation of flows leading to a mismatch with the expected timing of small water orders arriving at Walgett within the model). To address this, the end of system flow requirement was placed above the point where orders are restricted. This change subsequently allowed some water users to access the water intended for the end of system. Significant model changes to address this may affect model calibration and would require similar changes to the base case model and other scenarios already completed. For this tranche of modelling, it is not proposed to attempt any model changes, and to note that the flow benefits in the Barwon-Darling (and possibly also the impacts to Namoi diversions) are likely understated.

For more information on model assumptions and limitations, see section 2.

5.3 Modelling results

5.3.1 Long term average diversions

The modelling results for the end of system -translucency approach in Table 18 and the end of system - high security account in

Table 19 show that long-term average diversions are reduced across the regulated tributary valleys due to the increase in releases from storages to provide end of system flow targets. These impacts vary across the valleys in response to the variation in flow rates and timing along each of the rivers.

The impact to long-term average diversions of the end of system - high security account is higher than for and of system - translucency releases, although it meets the end of system flow target more often, as shown in Figure 15 (in section 5.2.1 above). The impact to long -term average diversions under the high security account approach is also significantly higher than modelled for the Panel due to the inclusion of a high security account and a 2-year reserve in each tributary valley.

The NSW Border Rivers is impacted by the end of system - high security account approach much more than the other valleys due to the comparatively high end of system flow target for the Border Rivers, and water for the account and reserve are only drawn from the NSW share of resources in the valley.

Barwon-Darling diversions increase due to additional inflows, which reduces the flow benefits being achieved. As noted in the description section, in reality the protection of the additional inflows using, for example, active management would be needed to protect additional inflows to realise the flow benefits along the Barwon-Darling, which we are unable to directly model at present but could potentially estimate with further work.

Table 18. End of system – translucency: change in long-term average annual diversions (1895-2023). Includes absolute change (GL/y) and relative change (%) from the base case.

Valley	Base case	EoS translucency	Absolute change	Relative change
	GL/y	GL/y	GL/y	%
Border Rivers	214.2	205.6	-8.6	-4.0%
Gwydir	446.2	436.1	-10.1	-2.3%
Namoi	252.6	247.4	-5.2	-2.1%
Macquarie	330.2	-	-	-
Barwon-Darling	171.3	172.4	+1.0	+0.6%

Table 19. End of system - high security account: change in long-term average annual diversions (1895-2023). Includes absolute change (GL/y) and relative change (%) from the base case.

Valley	Base case	EoS HS accounts	Absolute change	Relative change
	GL/y	GL/y	GL/y	%
Border Rivers	214.2	161.4	-52.8	-24.6%
Gwydir	446.2	422.4	-23.8	-5.3%
Namoi	252.6	242.0	-10.6	-4.2%
Macquarie	330.2	-	-	-
Barwon-Darling	171.3	173.3	+1.9	+1.1%

The changes in long term average diversions for each licence category are shown in Table 20 and Table 21, indicating that nearly all the impacts across the valleys are to general security water use.

This is due to the reduction in the remaining water available within the storage for general security allocations following the releases of additional water to meet the end of system flow targets.

There are some small increases in supplementary access water use in the NSW Border Rivers (end of system - translucency) and the Namoi River (both approaches). These small increases in the Namoi are due to the issue with the order restriction configured in the lower river as noted above. For the NSW Border Rivers, the combination of a single translucent release rule that does not vary with antecedent conditions and the higher end of system flow target are resulting in small amounts of supplementary access being triggered in the model.

As noted above, Barwon-Darling diversions increase due to additional inflows that are not able to be protected with the current model configuration, which reduces the flow benefits being achieved.

Table 20. End of system targets – translucency: change in long-term average diversions for each licence category (1895 – 2023). Includes absolute change (GL/y) and relative change (%) from the base case.

Valley	General security		Supp. or class A/B/C*		Floodplain harvesting	
	GL/y	%	GL/y	%	GL/y	%
Border Rivers	-8.5	-9.1%	+0.3	+0.4%	-0.4	-0.7%
Gwydir	-9.1	-4.6%	-0.8	-0.8%	-0.2	-0.1%
Namoi	-5.1	-3.8%	+0.1	+0.2%	-0.3	-0.3%
Macquarie	-	-	-	-	-	-
Barwon-Darling	-	-	+1.0	+0.7%	0.0	0.0%

* Supplementary (supp.) access occurs in the Border Rivers, Gwydir, Namoi and Macquarie valleys. Class A/B/C access occurs in the Barwon-Darling.

Table 21. End of system – high security account: change in long term average diversions for each licence category (1895 – 2023). Includes absolute change (GL/y) and relative change (%) from the base case.

Valley	General security		Supp. or class A/B/C*		Floodplain harvesting	
	GL/y	%	GL/y	%	GL/y	%
Border Rivers	-50.5	-54.2%	-1.9	-2.7%	-0.3	-0.7%
Gwydir	-22.3	-10.6%	-1.1	-1.2%	-0.3	-0.2%
Namoi	-10.4	-7.7%	+0.2	+0.5%	-0.4	-0.6%
Macquarie	-	-	-	-	-	-
Barwon-Darling	-	-	+1.9	+1.4%	0.0	+0.1%

* Supplementary (supp.) access occurs in the Border Rivers, Gwydir, Namoi and Macquarie valleys. Class A/B/C access occurs in the Barwon-Darling.

5.3.2 Annual diversions

The impacts on water users varies across years, with impacts occurring in most years. Individual year impacts are much more significant under the end of system – high security account approach. To show the variability of impacts across all years of the model run, the annual base case diversions and the changes to these that are modelled for each valley are shown in Figure 16 to Figure 19 for the end of system -translucency and in Figure 20 to Figure 23 for the end of system - high security account.

End of system - translucency

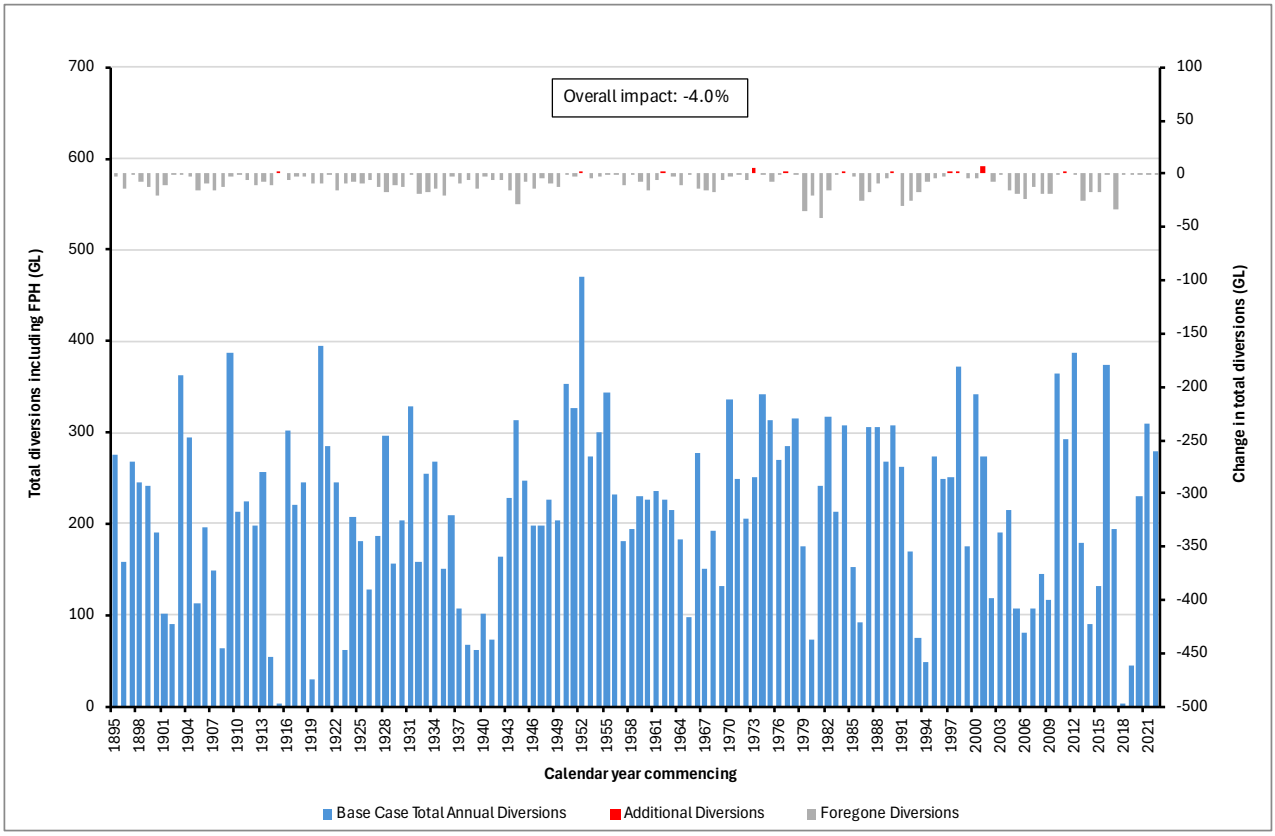

Figure 16. NSW Border Rivers annual base case diversions and changes arising from end of system - translucency (1895-2023)

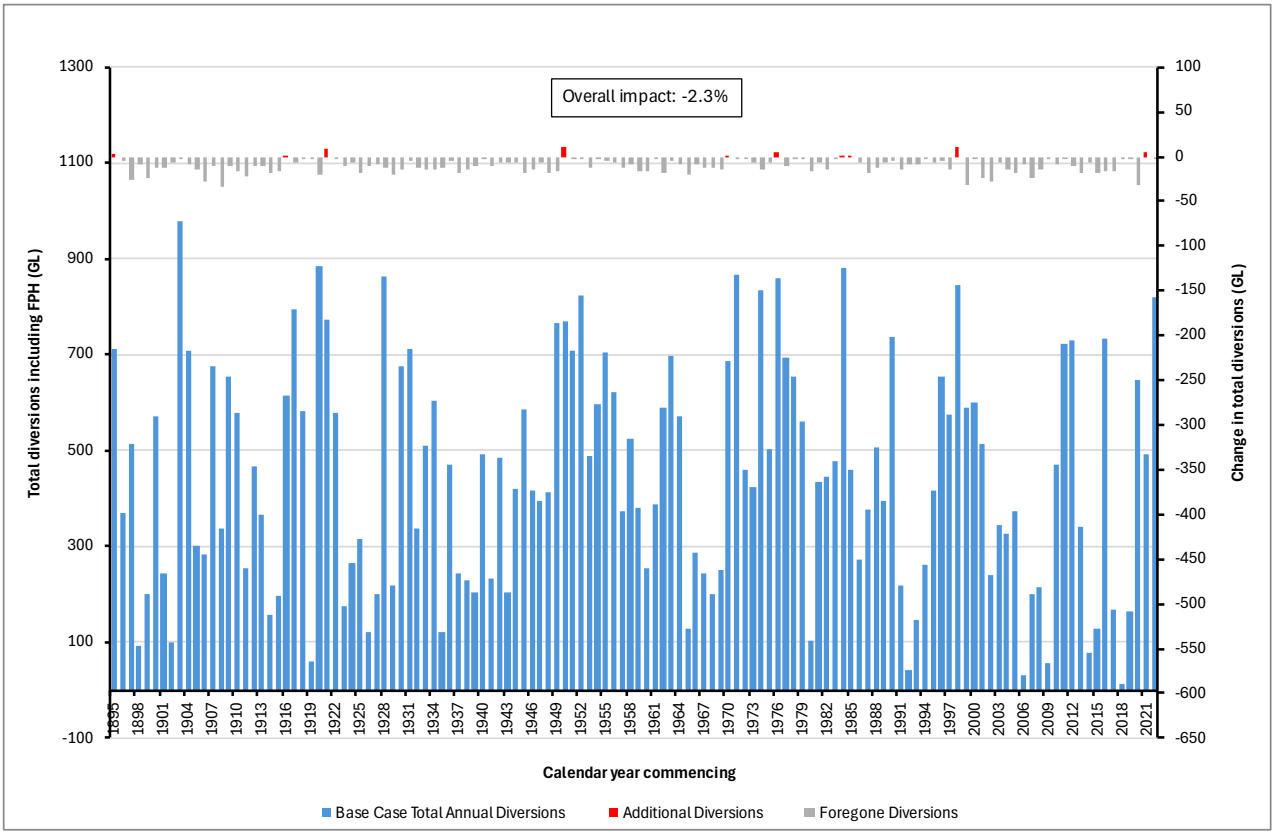

Figure 17. Gwydir annual base case diversions and changes arising from end of system - translucency (1895-2023)

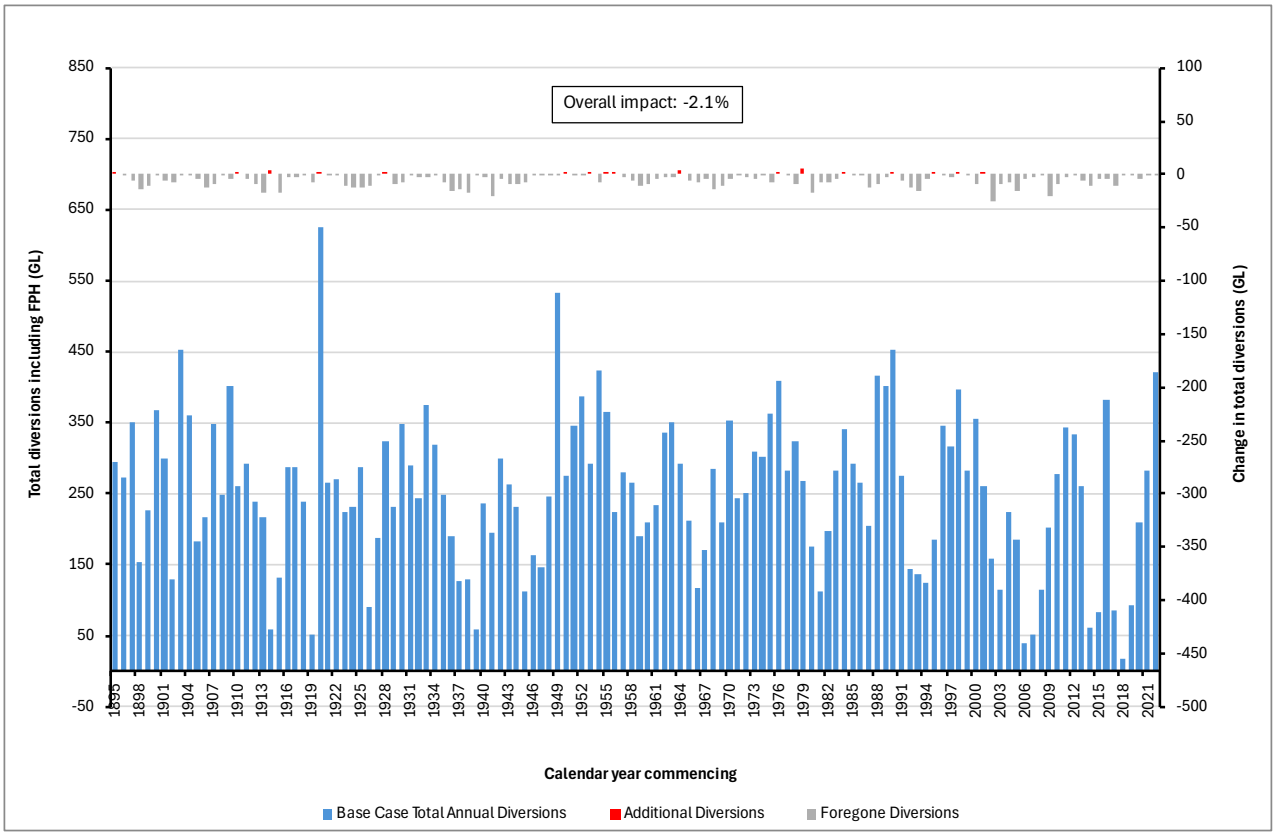

Figure 18. Namoi annual base case diversions and changes arising from end of system - translucency (1895-2023)

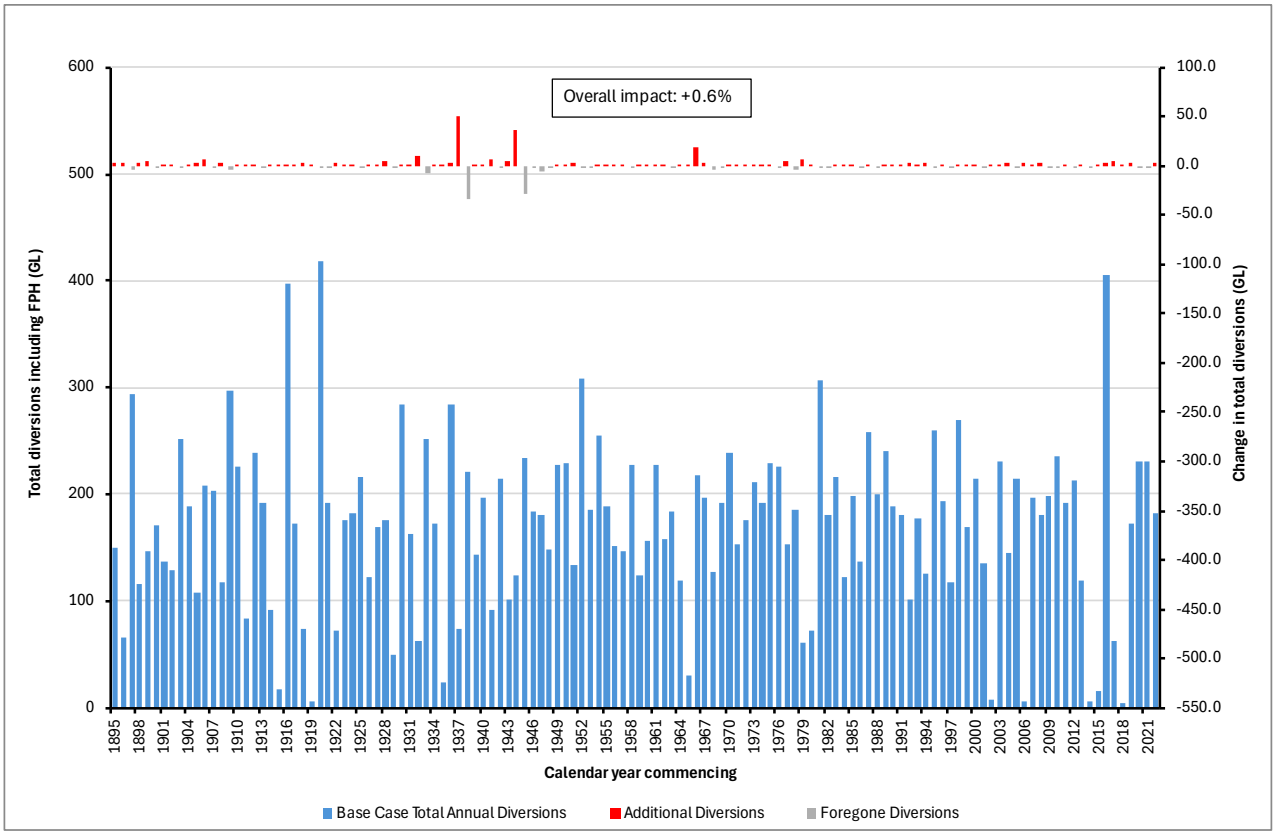

Figure 19. Barwon-Darling annual base case diversions and changes arising from end of system - translucency (1895-2023)

End of system - high security account

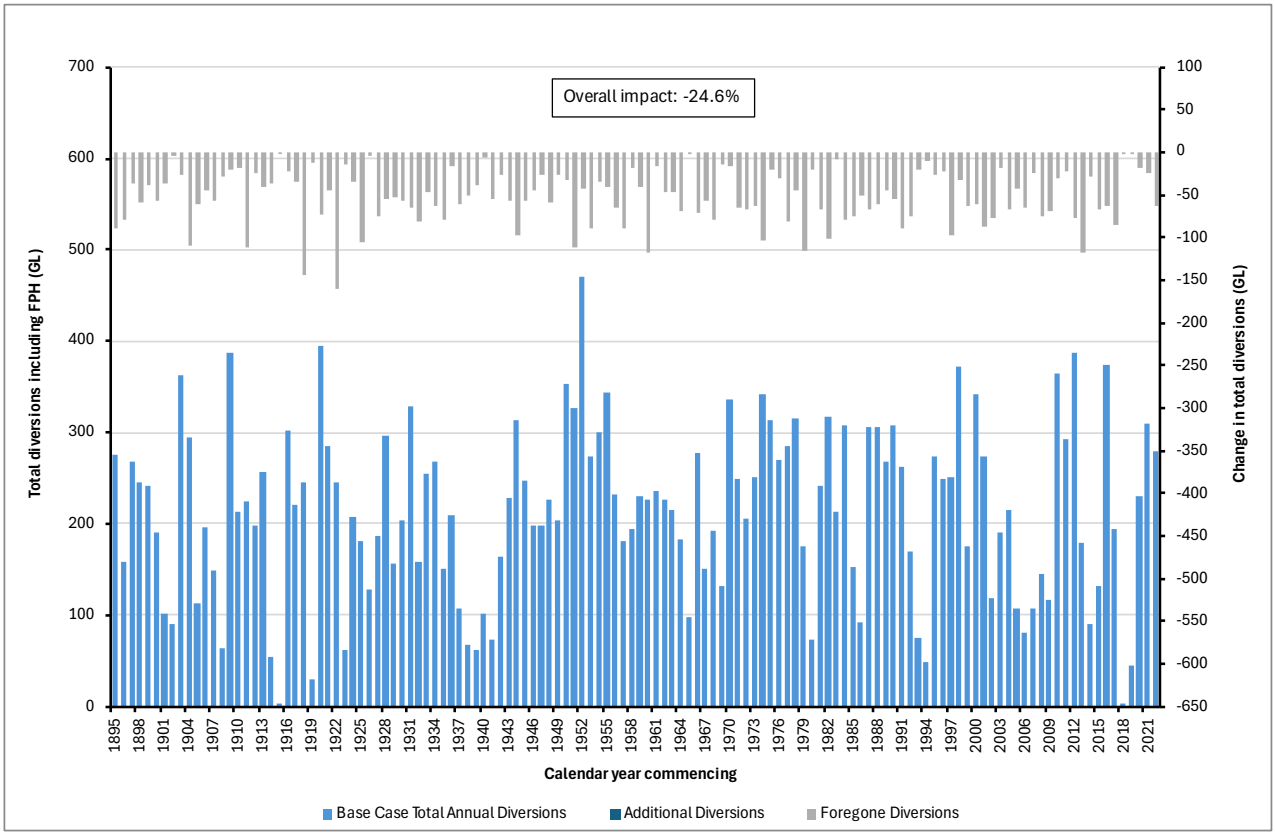

Figure 20. NSW Border Rivers annual base case diversions and changes arising from end of system – high security account. (1895-2023)

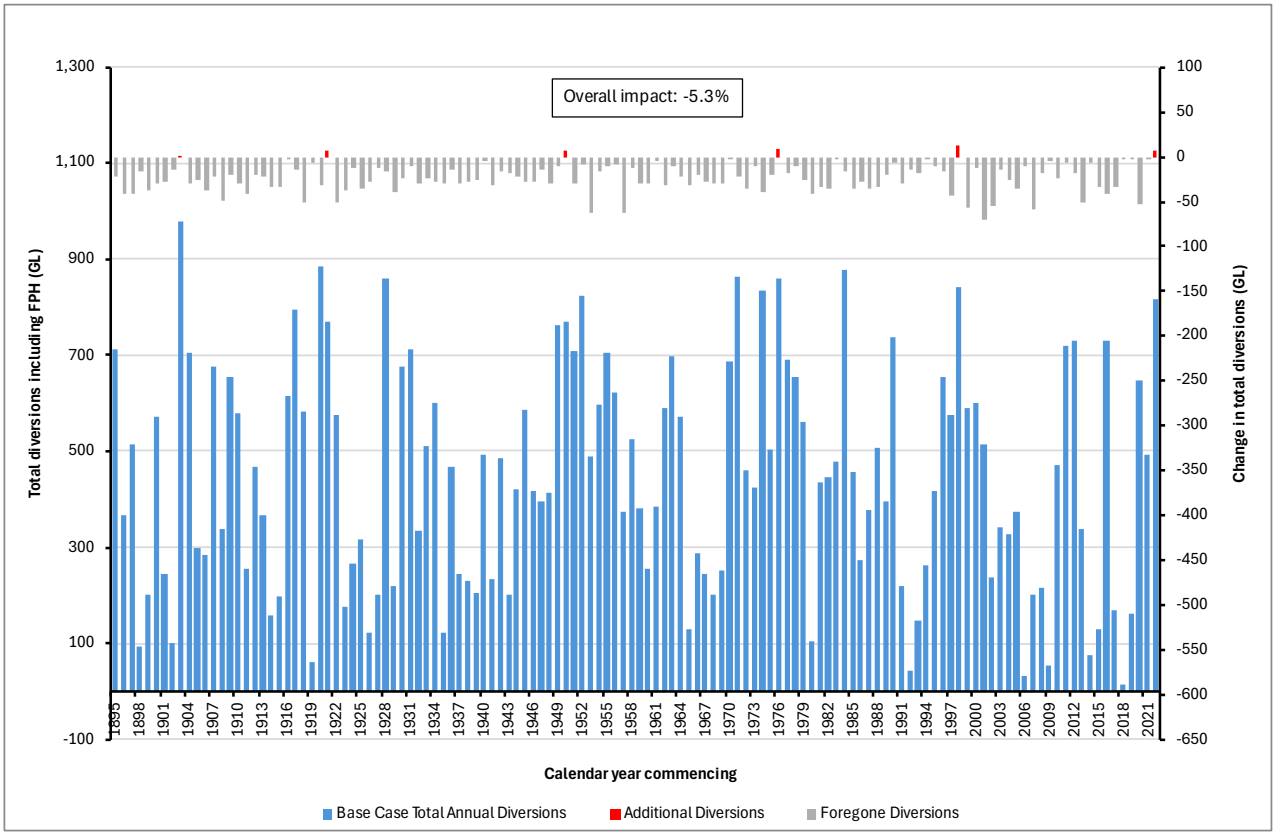

Figure 21. Gwydir annual base case diversions and changes arising from end of system – high security account. (1895-2023)

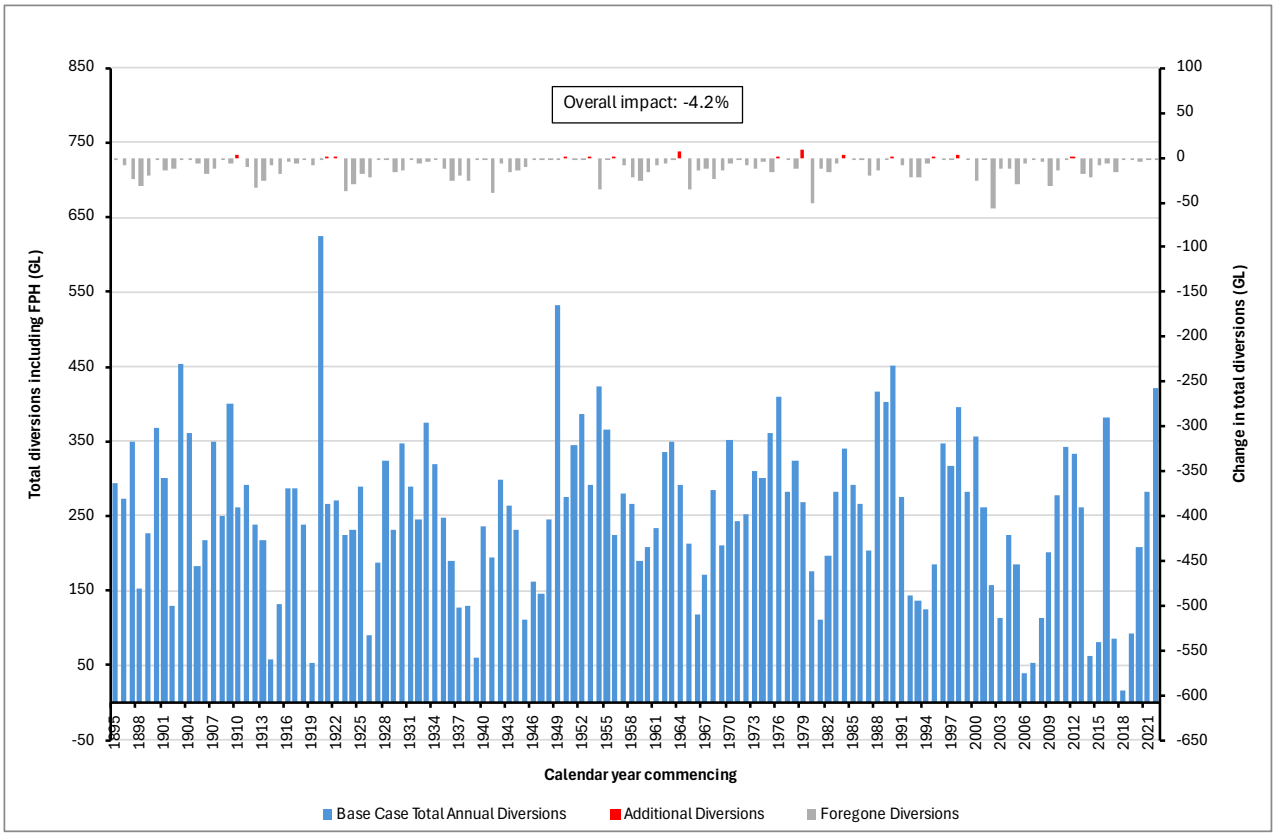

Figure 22. Namoi annual base case diversions and changes arising from end of system – high security account (1895-2023)

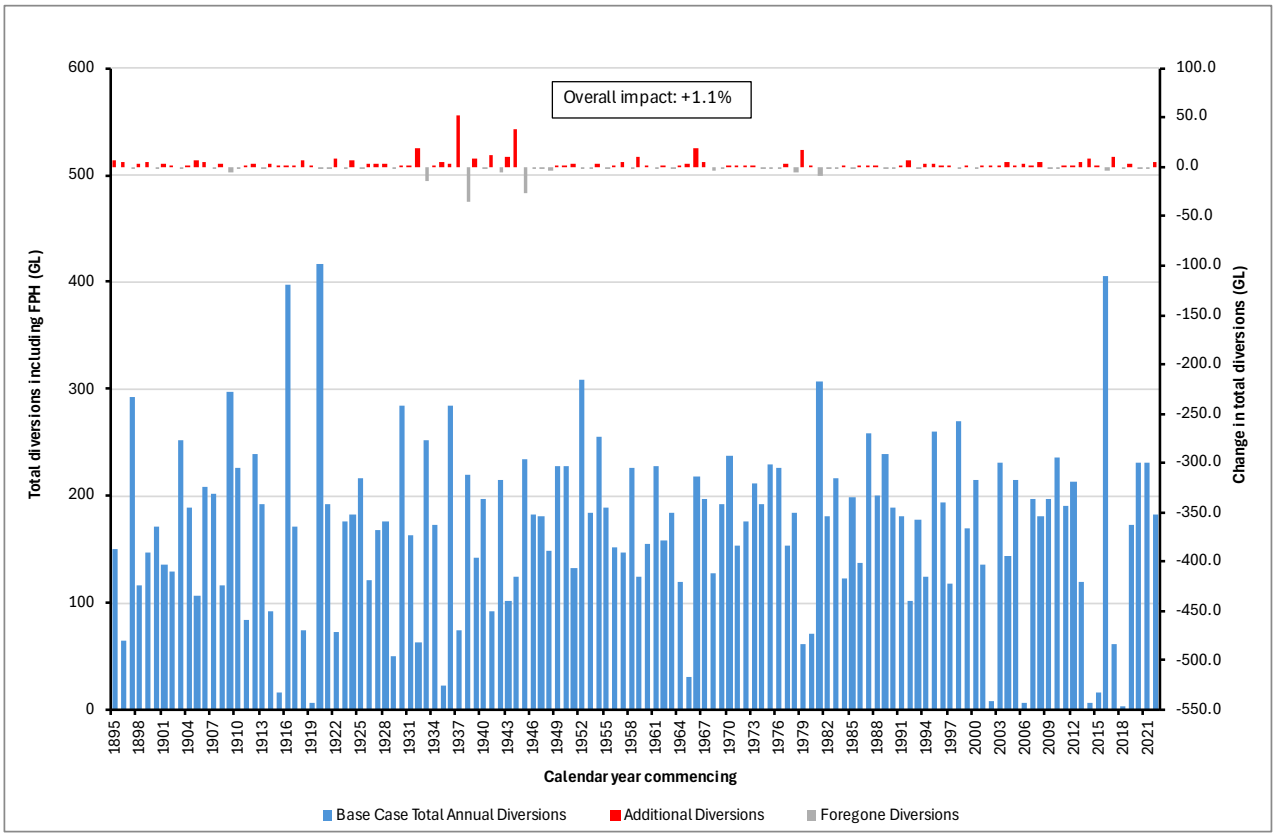

Figure 23. Barwon-Darling annual base case diversions and changes arising from end of system – high security account (1895-2023)

6 Connectivity environmental water allowance

The Panel recommended that a connectivity environmental water allowance should be established in the Border Rivers, Gwydir and Namoi regulated water sharing plans to provide for replenishment flows during dry times to maintain system health and water quality, following additional analysis of volume needs, benefits and impacts.

6.1 Panel's objective and proposed approach

The Panel recommended that the Gwydir, Namoi and Border Rivers regulated water sharing plans should include a 'connectivity' environmental water allowance (EWA) to provide pulses as needed for water quality and other environmental outcomes during dry times.

Historically, extended dry periods have occurred across the northern Basin. The MDBA has identified ecological 'thresholds of concern', which they used to develop recommended maximum cease to flow durations. These durations are aimed at preventing cease to flows periods longer than those identified in the 'without development' modelling. The long-term water plan also identifies maximum cease to flow values.

The panel proposed establishing a connectivity EWA in the Border Rivers, Gwydir and Namoi regulated water sharing plans to allow releases from dams to mitigate risks during such extended cease to flow periods in the Barwon-Darling. The connectivity EWA should provide adequate water for periodic 'pulsing' during extended dry times to maintain connectivity within the valleys for critical ecological and human needs. It was not proposed that the connectivity EWA would apply in the Macquarie as the regulated river in this valley discharges into the Macquarie Marshes rather than the Barwon-Darling River.

The Panel recommended that the connectivity EWA should have the highest security status and therefore take precedence in the dam storage so that it can be used when it is required.

6.2 Scenario description – what was modelled

The panel recommended that the managers of the connectivity EWA water should have the flexibility to use the water as they deem most effective to achieve connectivity outcomes. This recognises that connectivity needs are dynamic and that the most beneficial use of water may vary depending on the prevailing climate conditions and antecedent conditions of the rivers. However, this flexibility cannot be modelled, as models require clear decision points based on specific triggers, to then undertake a defined release action to achieve an outcome.

Action 3.3 from the Western Regional Water Strategy was to further investigate ways to provide a replenishment flows from the northern tributaries during dry periods. The Panel supported this approach and suggested it should be achieved through a connectivity EWA.

Two approaches for achieving the connectivity EWA have been modelled

- connectivity EWA - dam inflow trigger: Up to 2 large releases each year triggered by dam inflows meeting the dry trigger. This is a modification of the replenishment flows approach analysed for the Western Regional Water Strategy
- connectivity EWA - Bourke flow trigger: Up to one smaller release each year triggered by resumption of flow rule restrictions at Bourke. This approach was developed in consultation with the inter-agency working group.

The connectivity EWA - dam inflow trigger provides for releases as a system is drying out and during dry times. The connectivity EWA - Bourke flow trigger provides for releases during dry times only.

For each approach a high security account has been configured in the model to represent an environmental water allowance.

Connectivity EWA - dam inflow trigger

For the connectivity EWA – dam inflow trigger, replenishment releases were triggered by the dam inflows falling below the 75th percentile, on average over 30 days. This is the same as the Panel's trigger for transitioning to dry time rules. This approach provided for releases to occur as the system was drying out and during dry times.

This approach modelled:

- up to two replenishments release of 20 GL made each year, in each valley
- the size of the replenishment releases was based on the modelling of replenishment flows done for the Western Regional Water Strategy. The target of the regional water strategy modelling was at least a week of flows at Bourke with peak flows above 972 ML/d (for up to 10 days), and at least 30 GL total event volume[33]. This is consistent with the resumption of flow lifting trigger in the Barwon-Darling water sharing plan.
- releases are triggered on 31 October and 28 February each year, if the inflows to the dam are less than the 75th percentile (the same dry trigger as the end of system target scenarios)
- critical dry condition triggers provide a basis for the flows that would be necessary for reconnecting pools in dry times.
- valleys can be triggered individually

The dates for making the releases were selected to help ensure pools were topped up before summer and to replenish pools at the end of summer.

Connectivity EWA – Bourke flow trigger

An alternative approach was also tested that had a common low flow trigger in the Barwon-Darling for all three valleys and targeted a smaller replenishment flow. This approach provides for releases during dry times only.

The approach modelled:

[33] NSW DPE (2022): Western Regional Water Strategy: Attachment 5 – Analysis on replenishment flows. Western Regional Water Strategy | NSW Government Water

- up to one smaller release each year triggered by low flows at Bourke
- releases are triggered when restrictions at Bourke under the resumption of flow rule are triggered (flow of less than 450 ML/d for 120 days)
- releases are made to target a flow of at least 500 ML/day at Bourke for 14 days
- all valleys are triggered and releases staggered to allow for different travel times to Bourke.

The target flow of 500 ML/d provides a flow rate of 0.04 m/s which has been identified as a critical velocity required to mix water within pools and prevent algal blooms forming (Mitrovic et al 2006) [34]. It also aligns with the hydrological aim of the Northern Basin Connectivity Event conducted by the Commonwealth Environmental Holder from April to July 2018[35]. This event was recommended by DPIRD- Fisheries as providing the best data point for delivering managed flows in a drying river. They also noted that early intervention was far preferable to waiting until the system was under significant stress to make the releases.

6.2.1 Model configuration and assumptions

Replenishment release

For both connectivity EWA approaches, the replenishment releases from each dam have been staggered for travel time to Bourke, so that the flows will align together in the Barwon-Darling River. This requires releases in the Border Rivers to commence first, then the Gwydir Valley 2 days later, and releases in the Namoi Valley to commence 8 days after the Border Rivers releases.

For the connectivity EWA – dam inflow trigger, the tributary river system models have each been configured to release water:

- to meet a target flow at the end of each tributary river system when inflows to the dam are below the dry inflow trigger on 31 October and 28 February each year
- over a 20-day period at the operational channel capacity at the lower end of each system: 1,000 ML/day for each valley. For the Gwydir valley, the target flow was split between the Mehi River (800 ML/day) and Gil Gil Creek (200 ML/day).

The models underestimate losses in dry times due to the use of a constant flow-loss relationship when simulating river flows, which represents losses under typical conditions. However, replenishment releases would be made in dry periods, when a significantly higher proportion of flows would be consumed in transmission along the rivers. To allow for this in modelling the connectivity EWA – Bourke trigger:

- the target flow at Bourke was doubled to 1,000 ML/day over a 14-day period
- each of the three tributary valleys was configured to target a flow of 500 ML/day at the end of the system. For the Gwydir valley, 400 ML/day ordered at the end of the Mehi River, and 100 ML/day at the end of Gil Gil Creek.

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[34] https://onlinelibrary.wiley.com/doi/abs/10.1002/rra.875

[35] Department of *Agriculture Water and the Environment (2108) Final* report on the Northern Connectivity Event (April – July 2018) The Northern Rivers - DCCEEW

Environmental water allowance

For both connectivity EWA approaches, a new high security account has been configured with sufficient volume to ensure the proposed replenishments could be delivered in each year. To meet requirements under the water sharing plans in each valley for maintaining supply, reserves for high security entitlements equivalent to 2 times the annual entitlement plus an allowance for 60% to cover delivery losses are required.

For the connectivity EWA – dam inflow trigger, each valley model was configured with a high security account to provide for up to two releases of up to 20,000 ML in each year, as shown in Table 22, together with the associated reserve requirement.

Table 22: Connectivity EWA – dam inflow trigger: high security account details (provides for up to 2 large releases a year).

Valley	Dam inflow trigger - high security environmental water allowance GL	2-year reserve increase GL
Border Rivers	40	128
Namoi	40	128
Gwydir (Gil Gil)	8	25.6
Gwydir (Near Coli)	32	102.4

For the connectivity EWA- Bourke flow trigger, each valley model was configured with a high security account to provide for one release of 10,000 ML in each year, as shown in Table 23, together with the associated reserve requirement.

Table 23: Connectivity EWA – Bourke flow trigger high security account details (provides for up to 1 small release a year)

Valley	Bourke flow trigger - high security environmental water allowance GL	2-year reserve increase GL
Border Rivers	10	32
Namoi	10	32
Gwydir (Gil Gil)	2	6.4
Gwydir (Near Coli)	8	25.6

Initial testing revealed a few issues that required adjustments to the models:

- The ordered flow rates are sufficiently large that some irrigation nodes are able to access some flows. This issue appears to arise due to the configuration of supplementary access within the Gwydir model. Some minor changes were made for the water users closest to the end of the system, which has partially addressed the issue. Significant model changes to address this may

affect model calibration and would require similar changes to the base case model and other scenarios already completed.

- The previously identified issue with the Namoi order restrictions required the replenishment flow orders to be placed above the point where orders were restricted, which subsequently provided some additional access to a few modelled water users closer to Walgett.

For this tranche of modelling, it is not proposed to attempt any model changes, and to note that the impacts to Gwydir diversions, and the flow benefits in the Barwon-Darling are likely understated. Similarly, it is not proposed to attempt any model changes to the Namoi valley, and to note that the impacts to Namoi diversions, and the flow benefits in the Barwon-Darling are likely understated.

These issues are less significant for the connectivity EWA - Bourke flow trigger, as the flows being delivered to the end of the system in each valley are about half the flow rates targeted in the connectivity EWA - dam inflow trigger.

For more information on model assumptions and limitations, see section 2.

6.3 Modelling results

Restriction periods

The intent of the Panel's connectivity EWA recommendation is to provide replenishment releases from the dams to break up dry periods in the Barwon-Darling River. Restrictions under the resumption of flow rule are triggered after prolonged periods below baseflow. We have looked how the replenishment releases under each of the connectivity EWA approaches, change the amount of time that the resumption of flow rule restriction trigger is met at Bourke. This has been used as a proxy to understand whether they could reduce the time the river is 'too dry for too long'. The resumption of flow restriction trigger assessed was the change in length of time when flows at Bourke were below 450 ML/d for 120 consecutive days[36].

Under the connectivity EWA - dam inflow trigger, with up to two larger releases in a year, we can see from Figure 24 that there are significantly fewer days of restrictions under the resumption of flow rule occurring in the scenario with replenishment flows, with an overall reduction of 38% in the number of days with restrictions at Bourke.

Under the Bourke flow trigger, with one smaller release in a year and a common trigger, we can see from Figure 25 that there are also significantly fewer days of restrictions under the resumption of flow rule occurring in the scenario with replenishment flows, with an overall reduction of 52% in the number of days with restrictions at Bourke. The connectivity EWA - Bourke flow trigger is more effective at reducing the days of restriction, as the resumption of flow rule itself is used as the trigger for replenishment releases, rather than the inflows to each valley storage.

[36] This is the existing Bourke restriction trigger in the Barwon-Darling water sharing plan. This trigger was the proxy used to assess the effectiveness of replenishment flows in the Western Regional Water Strategy – Attachment 5: Analysis of replenishment releases. Western Regional Water Strategy | NSW Government Water

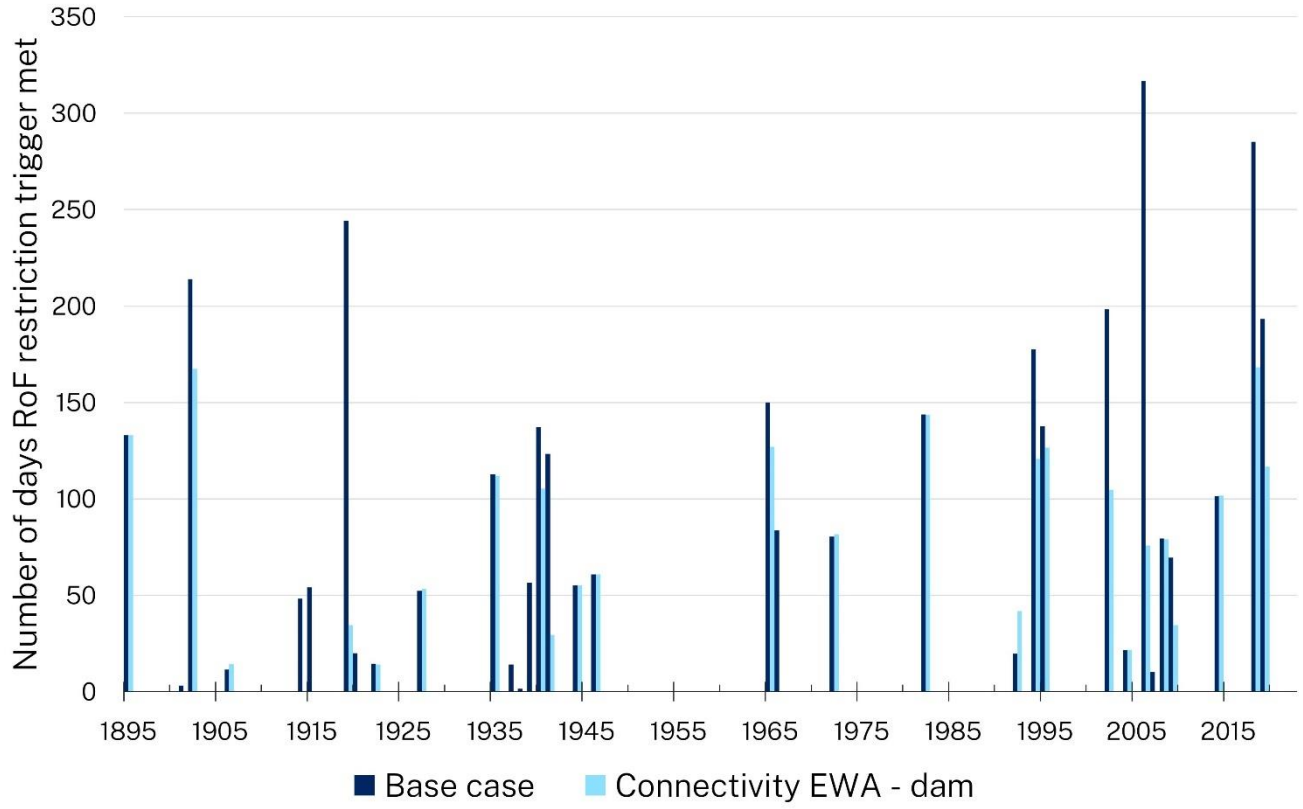

Figure 24: Connectivity EWA - dam inflow trigger. Periods of restriction in the Barwon-Darling at Bourke under the resumption of flow rules, compared with the base case

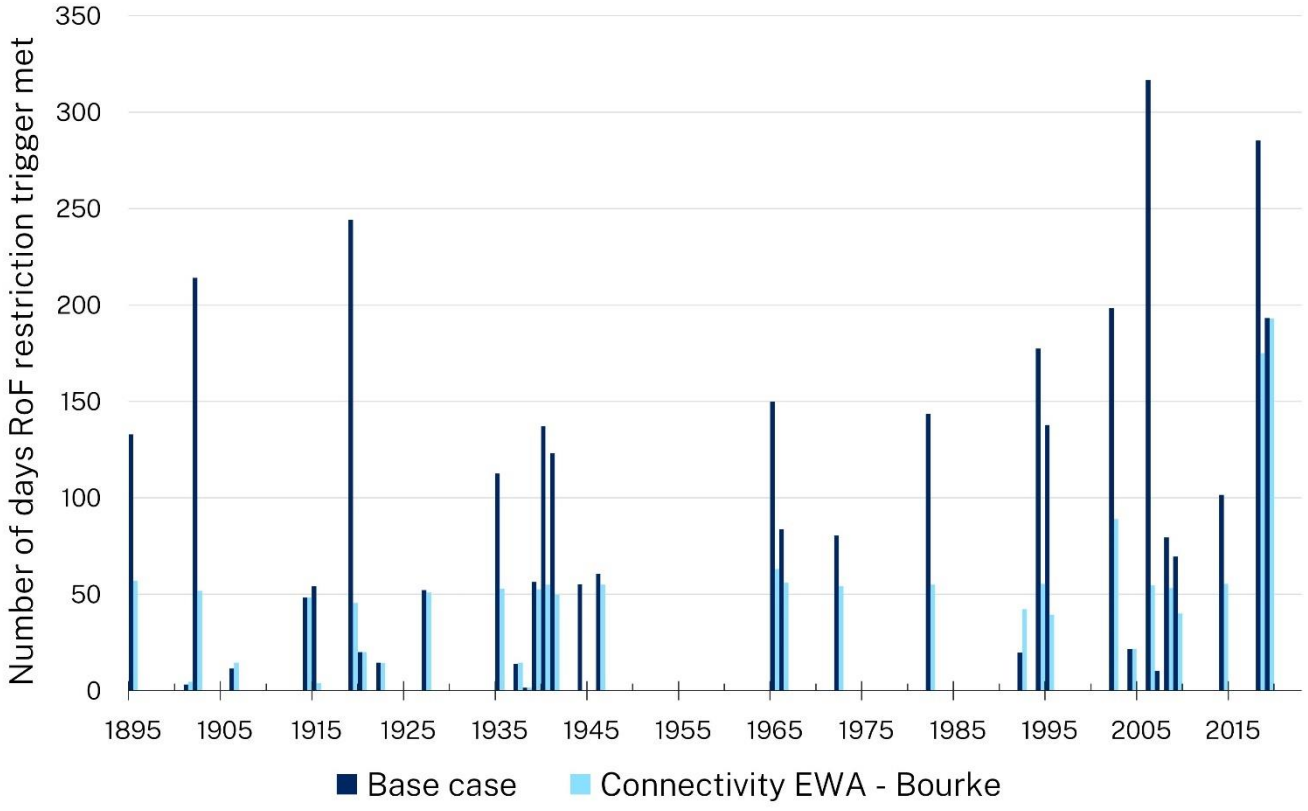

Figure 25. Connectivity EWA – Bourke flow trigger. Periods of restriction in the Barwon-Darling at Bourke under the resumption of flow rules, compared with the base case

Connectivity EWA – dam inflow trigger

The connectivity EWA - dam inflow trigger used a trigger based on the storage inflows to each tributary valley. Model results in Table 24 and Table 25 indicate that each valley has a similar number of replenishment releases triggered, although most replenishment 'events' have only one valley triggering at a time, and 59% of years have at least one replenishment release in one of the valleys.

The variation in the number of valleys with a replenishment releases triggered produced a wide range of flows in the Barwon-Darling River system, with peak flows at Bourke typically ranging from 1,000 ML/day to 3,500 ML/day.

Table 24. Connectivity EWA – dam inflow trigger: frequency of replenishment releases across valleys (up to 2 large releases using dam inflow trigger)

Number of Valleys triggered	Anytime		October		February	
	Number of events	Proportion of total events	Number of events	Proportion of October events	Number of events	Proportion of February events
3 valleys	15	6%	11	9%	4	3%
2 valleys	30	12%	17	13%	13	10%
1 valley	50	20%	22	17%	28	22%

Table 25. Connectivity EWA – dam inflow trigger: frequency of replenishment releases by valley (up to 2 large releases using dam inflow trigger)

	Total		October		February	
Number of releases	Number of events	Proportion of total events	Number of events	Proportion of October events	Number of events	Proportion of February events
Years with two releases	5	4%	5	4%	6	5%
Years with one release	42	33%	39	30%	42	33%
Years with any release	47	37%	44	34%	48	38%
Total releases	52	-	49	-	54	-

Connectivity EWA – Bourke flow trigger

The connectivity EWA - Bourke flow trigger used the trigger for the resumption of flow rule restrictions at Bourke that is contained in the Barwon-Darling water sharing plan as a single trigger for replenishment releases to be made in each tributary valley. This produced a total of 29 replenishment events over the 128 years of model simulation.

At Bourke, these release events typically produced:

- a peak flow at Bourke between 1,500 ML/day and 2,500 ML/day, depending on variations in other tributary inflows, and
- flows above 1,000 ML/day between 14 and 18 days.

Four of the events were overtaken by larger natural flow events, and one event triggered in 2019 was unable to be supplied due to supplies being exhausted in the Namoi valley, and the target flow only partially able to be supplied from the Gwydir valley. Some events were not able to provide a target flow for at least 14 days due to the effects of pumping in the Barwon-Darling, as the model is not currently able to simulate operational processes such as active management that would provide protection for the replenishment releases.

6.3.1 Long term average diversions

The modelling results show that long-term average diversions are reduced across all tributary valleys under both the connectivity EWA – dam inflow trigger (Table 26) and connectivity EWA – Bourke flow trigger (Table 27) due to the increased releases from storages to provide replenishment flows in drier periods. These impacts vary across the valleys in response to the variation in flow rates and timing along each of the rivers.

In both approaches, the impacts to Gwydir water users are considerably lower than for the Namoi and Border Rivers. Further investigation has revealed that the ordered flow rates are large enough that some irrigation nodes are able to access some flows.

This issue appears to arise due to the configuration of supplementary access within the Gwydir model and is more significant for the connectivity EWA – dam inflow trigger due to the higher flows being targeted. Some minor changes were made for the water users closest to the end of the system, which has partially addressed the issue. Significant model changes to address this may affect model calibration and would require similar changes to the base case model and other scenarios already completed. For this tranche of modelling, it is not proposed to attempt any model changes, and to note that the impacts to Gwydir diversions, and the flow benefits in the Barwon-Darling are likely understated.

The previously identified issue with the Namoi order restrictions required the replenishment flow orders to be placed above the point where orders were restricted, which subsequently provided some additional access to a few modelled water users closer to Walgett. Similarly for the Gwydir modelling issues, it is not proposed to attempt any model changes, and to note that the impacts to Namoi diversions, and the flow benefits in the Barwon-Darling are likely understated.

Under both approaches, the Barwon-Darling diversions increase due to additional inflows that are not protected from diversion in the model, which reduces the flow benefits being achieved. In reality, something like active management would need to be used to protect additional inflows to realise the flow benefits along the Barwon-Darling. This is something we are unable to directly model at present but could potentially estimate with further work.

Table 26. Connectivity EWA – dam inflow trigger: change in long-term average annual diversions (1895-2023). Includes absolute change (GL/y) and relative change (%) from the base case.

Valley	Base case GL/y	EWA - dam GL/y	Absolute change GL/y	Absolute change %
Border Rivers	214.2	187.2	-27.0	-12.6%
Gwydir	446.2	431.9	-14.2	-3.2%
Namoi	252.6	232.7	-19.9	-7.9%
Macquarie	330.2	-	-	-
Barwon-Darling	171.3	173.4	+2.1	+1.2%

Table 27. Connectivity EWA – Bourke flow trigger: change in long-term average annual diversions (1895-2023). Includes absolute change (GL/y) and relative change (%) from the base case.

Valley	Base case GL/y	EWA - Bourke GL/y	Absolute change GL/y	Absolute change %
Border Rivers	214.2	207.4	-6.8	-3.2%
Gwydir	446.2	442.6	-3.6	-0.8%
Namoi	252.6	246.9	-5.7	-2.3%
Macquarie	330.2	-	-	-
Barwon-Darling	171.3	172.2	+0.9	+0.5%

The changes in long term average diversions for both approaches for each licence category are shown in Table 28 and Table 29 indicating that nearly all the impacts across the tributary valleys are to general security water use. This is due to the reduction in the remaining water available within the storage for general security allocations following the reserving and releasing of additional water to provide the replenishment releases.

Table 28. Connectivity EWA – dam inflow trigger: change in long-term average annual diversions for each licence category (1895 – 2023). Includes absolute change (GL/y) and relative change (%) from the base case.

Valley	General security		Supp. or class A/B/C*		Floodplain harvesting	
	GL/y	%	GL/y	%	GL/y	%
Border Rivers	-26.3	-28.2%	-0.9	-1.3%	+0.1	+0.3%
Gwydir	-14.7	-7.0%	+0.6	+0.7%	-0.1	-0.1%
Namoi	-20.0	-14.9%	+0.7	+1.9%	-0.5	-0.6%
Macquarie	-	-	-	-	-	-
Barwon -Darling	-	-	+2.3	+1.6%	-0.2	-0.7%

* Supplementary (supp.) access occurs in the Border Rivers, Gwydir, Namoi and Macquarie valleys. Class A/B/C access occurs in the Barwon-Darling.

Table 29. Connectivity EWA – Bourke flow trigger: change in long-term average annual diversions for each licence category (1895 – 2023). Includes absolute change (GL/y) and relative change (%) from the base case.

Valley	General security		Supp. or class A/B/C*		Floodplain harvesting	
	GL/y	%	GL/y	%	GL/y	%
Border Rivers	-6.4	-6.8	-0.4	-0.5	0	0.0
Gwydir	-3.8	-1.8	+0.3	+0.3	-0.1	-0.1
Namoi	-5.7	-4.2	+0.1	+0.3	-0.2	-0.2
Macquarie	-	-	-	-	-	-
Barwon-Darling	-	-	+1.0	+0.7	-0.1	-0.2

*Supplementary (supp.) access occurs in the Border Rivers, Gwydir, Namoi and Macquarie valleys. Class A/B/C access occurs in the Barwon-Darling.

6.3.2 Annual diversions

The impacts on water users varies across years, with impacts occurring in most years. Individual year impacts are more significant under the connectivity EWA - dam inflow with larger replenishment releases occurring more often. To show the variability of impacts across all years of the model run, the annual diversions for each valley are shown in Figure 26 to Figure 29, with the base case diversions and the changes to these that are modelled using connectivity EWA - dam inflow trigger. Figure 30 to Figure 33 show the annual base case diversions and the changes to these that are modelled using the connectivity EWA - Bourke flow trigger.

Connectivity EWA – dam inflow trigger

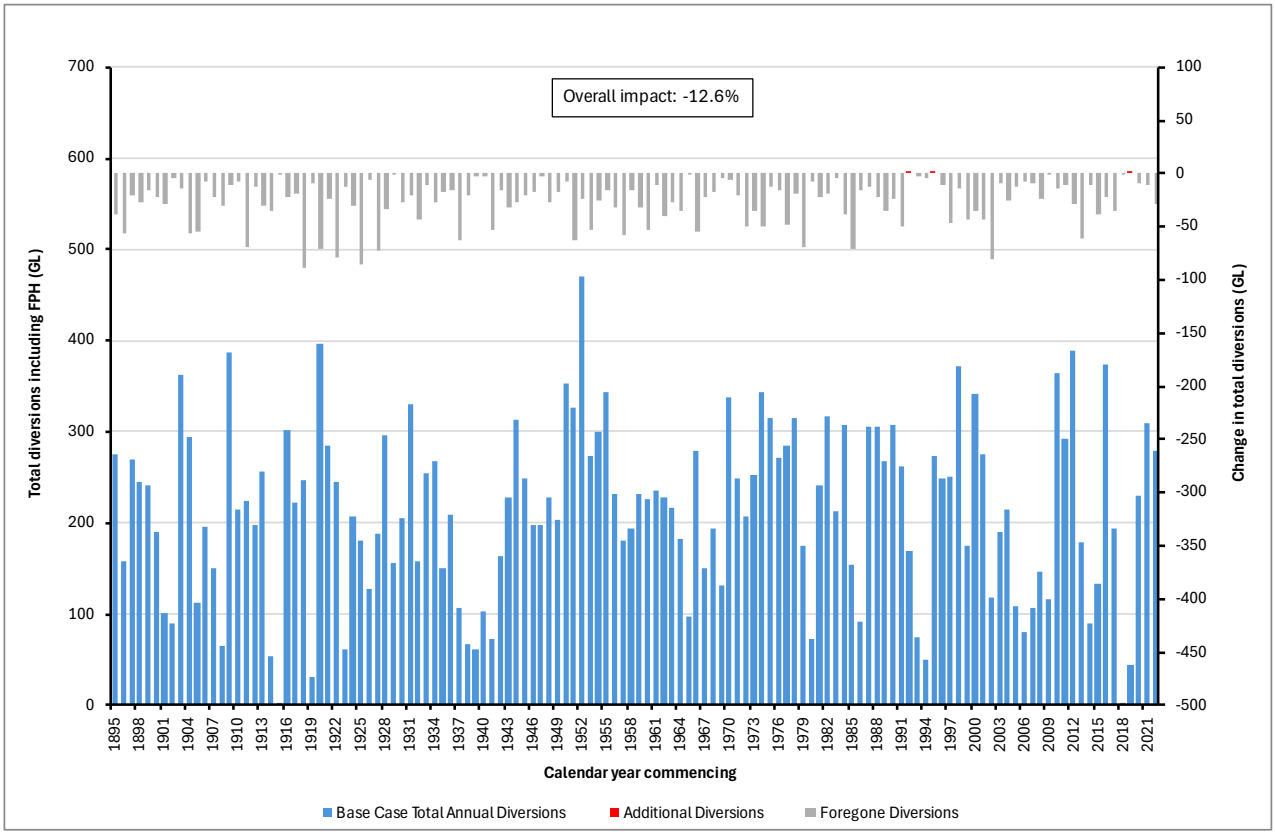

Figure 26. NSW Border Rivers annual base case diversions and changes arising from the Connectivity EWA - dam inflow trigger (1895-2023)

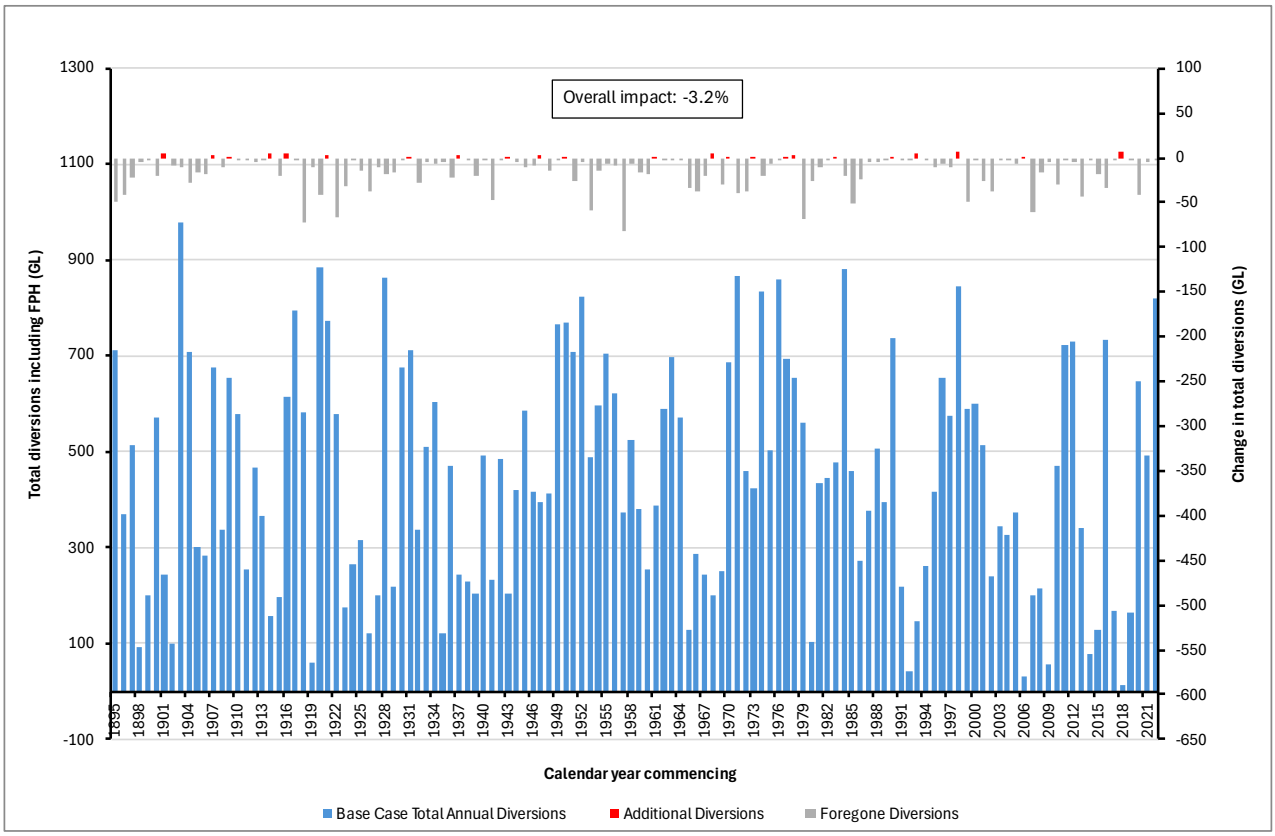

Figure 27. Gwydir annual base case diversions and changes arising from the Connectivity EWA - dam inflow trigger (1895-2023)

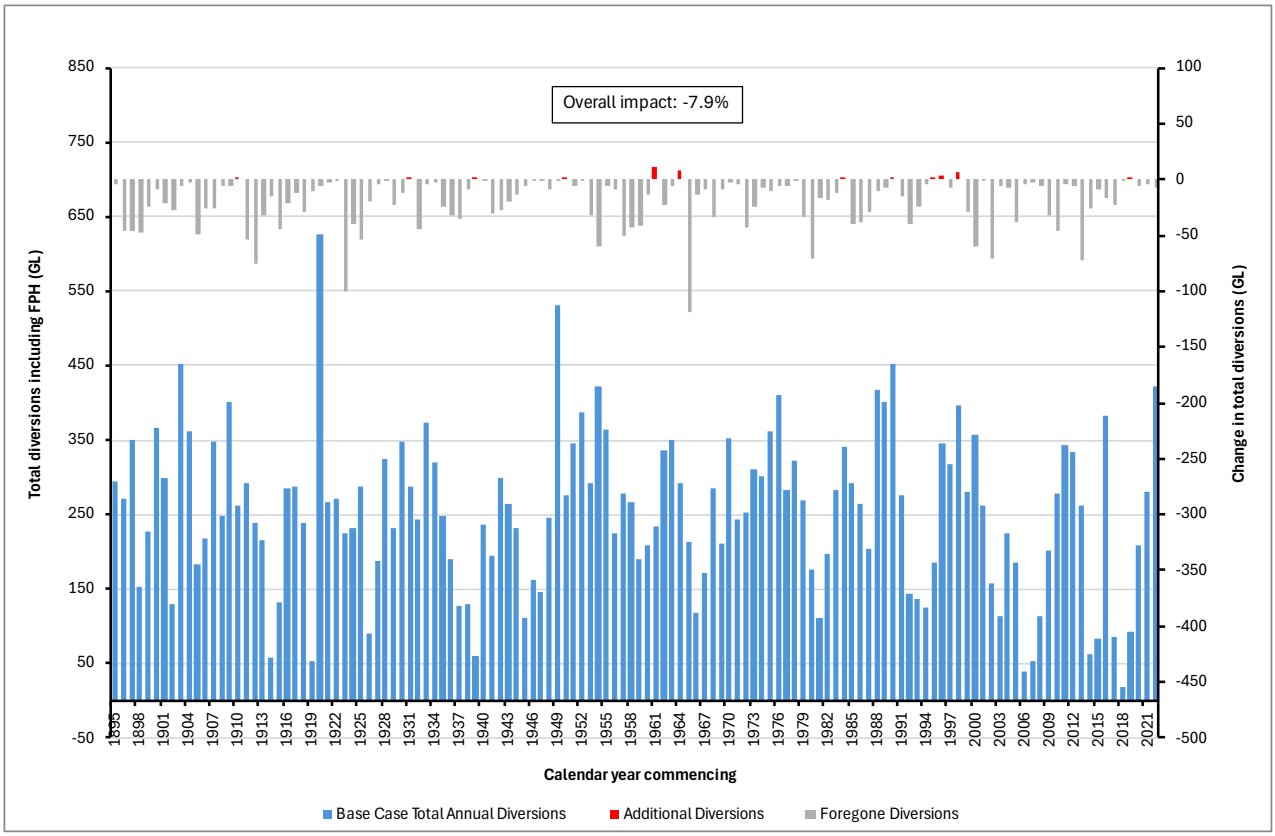

Figure 28. Namoi annual base case diversions and changes arising from the Connectivity EWA - dam inflow trigger (1895-2023)

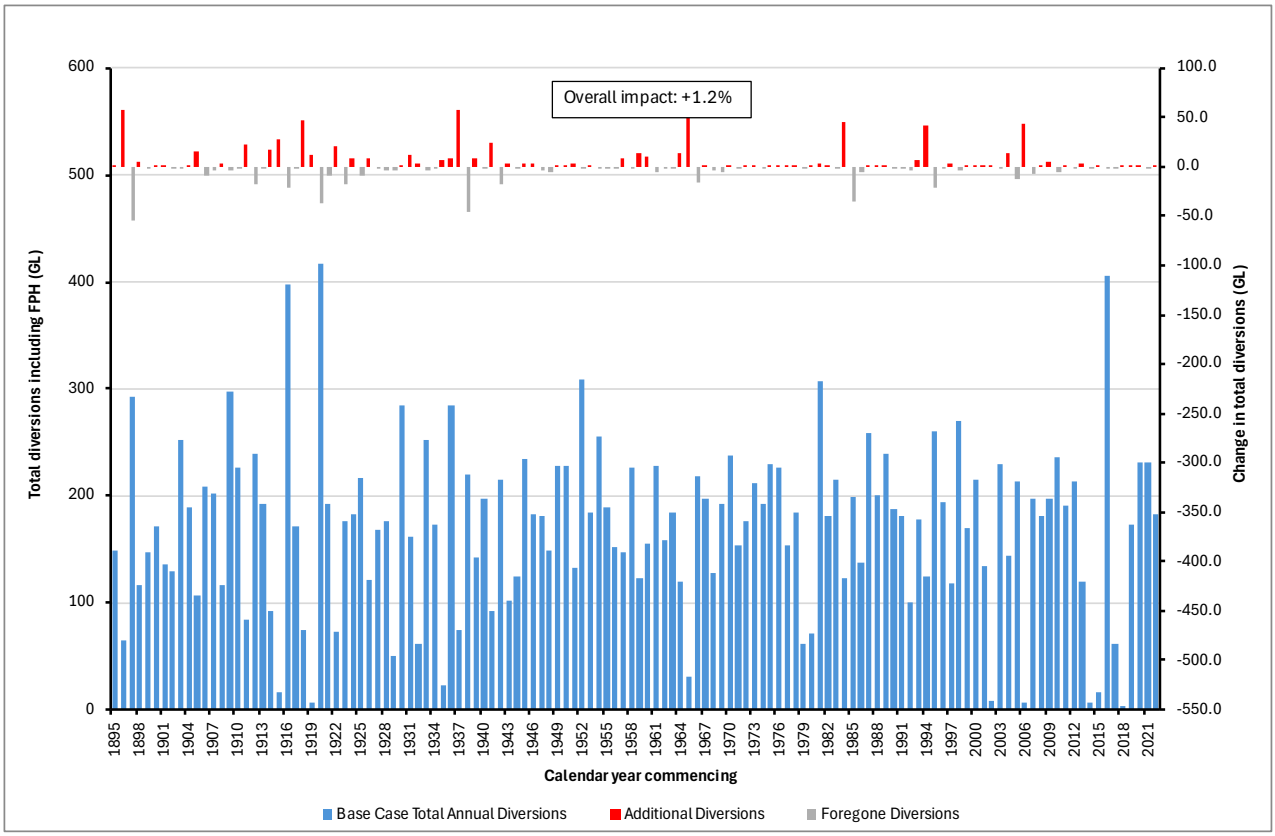

Figure 29. Barwon-Darling annual base case diversions and changes arising from the Connectivity EWA - dam inflow trigger (1895-2023)

Connectivity EWA Bourke flow trigger

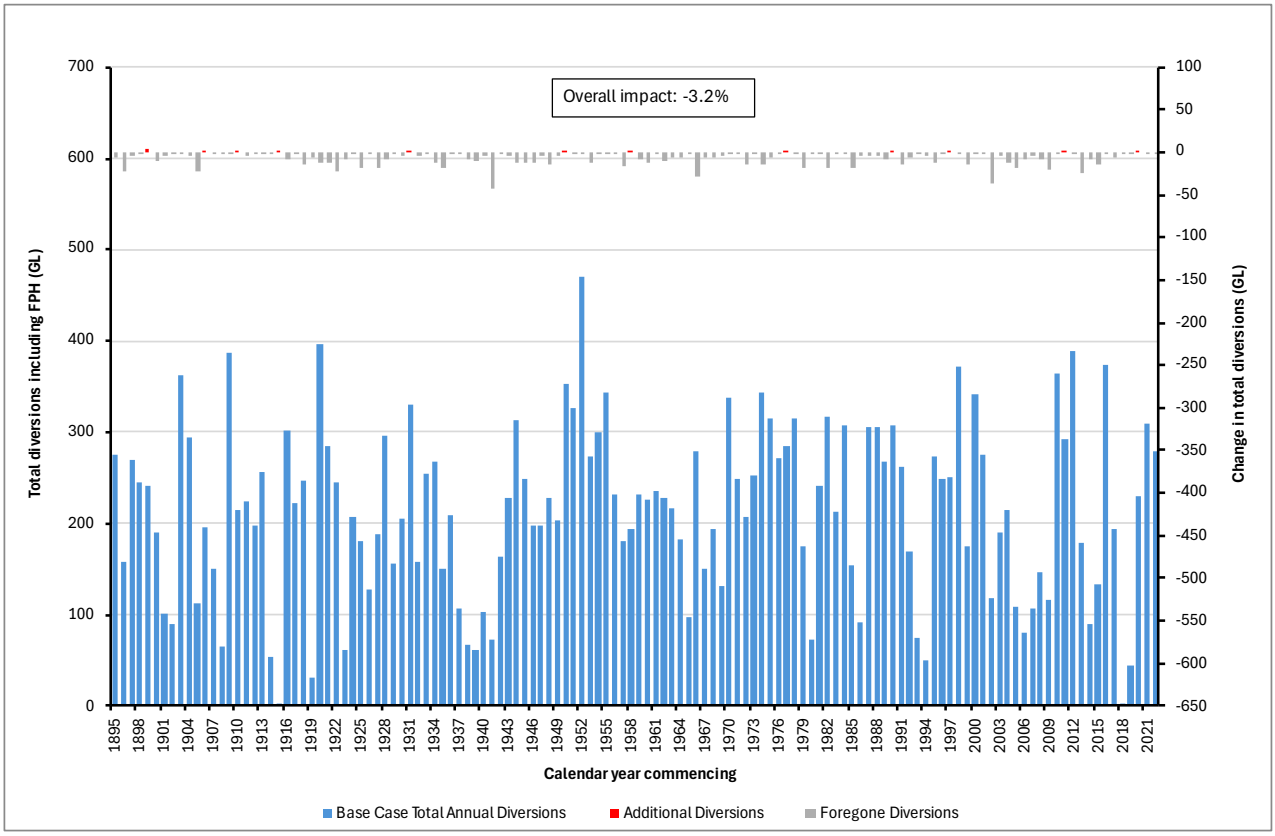

Figure 30. NSW Border Rivers annual base case diversions and changes arising from the Connectivity EWA – Bourke flow trigger (1895-2023)

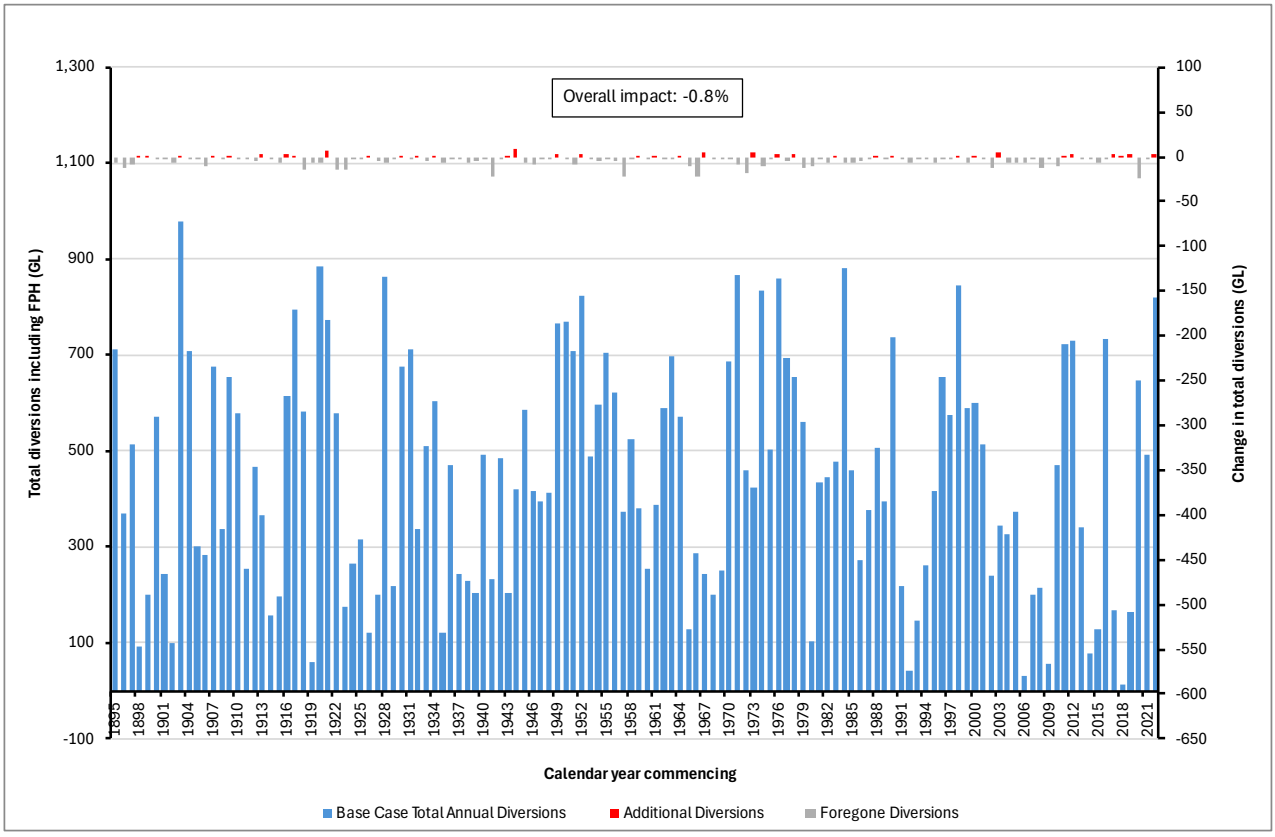

Figure 31. Gwydir annual base case diversions and changes arising from the Connectivity EWA – Bourke flow trigger (1895-2023)

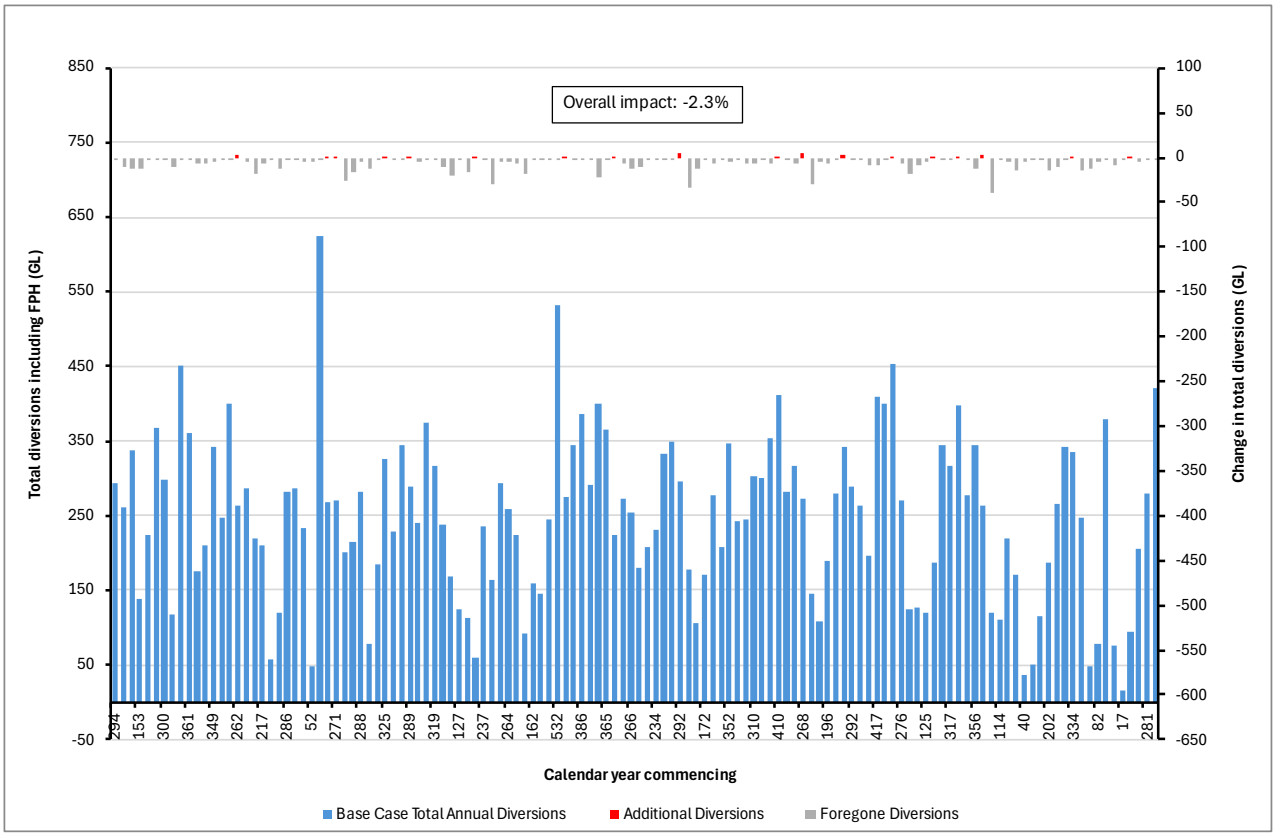

Figure 32. Namoi annual base case diversions and changes arising from the Connectivity EWA – Bourke flow trigger (1895-2023)

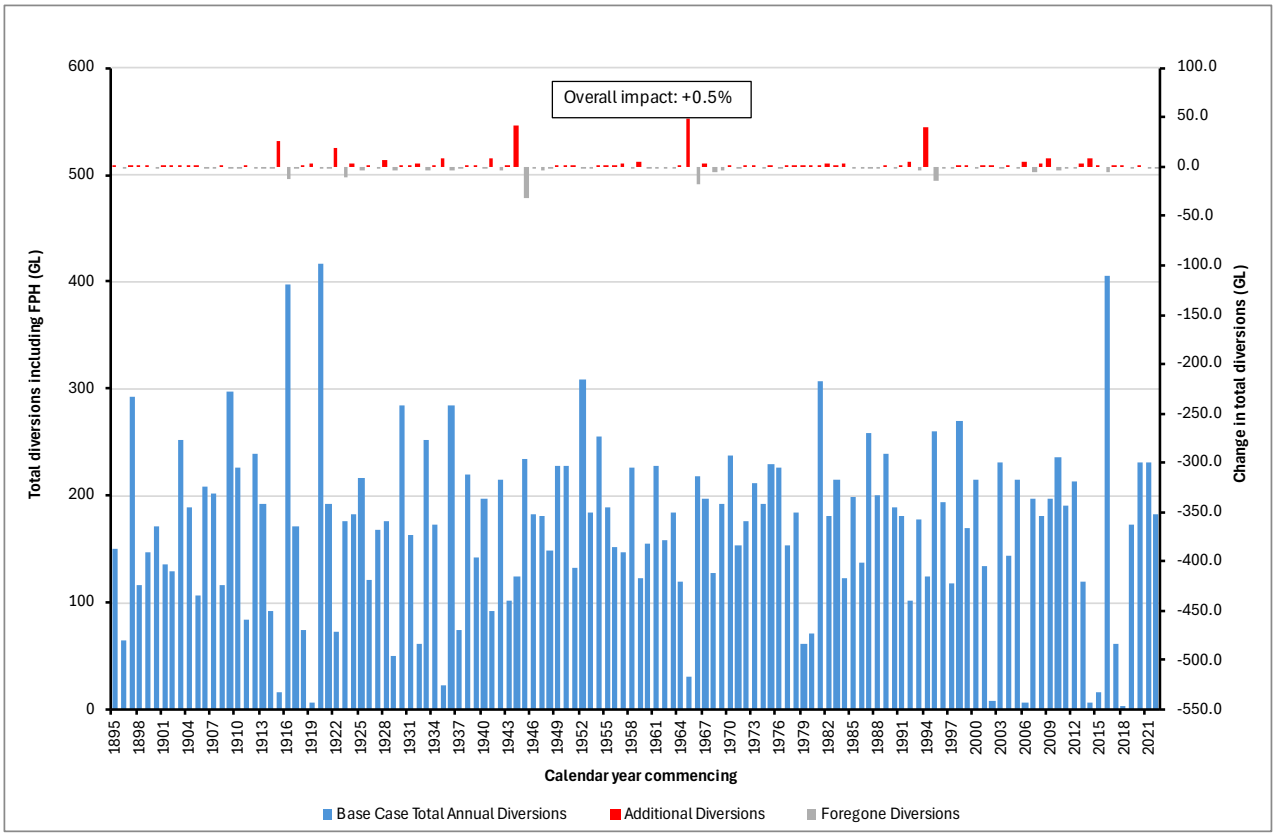

Figure 33. Barwon-Darling annual base case diversions and changes arising from the Connectivity EWA – Bourke flow trigger (1895-2023)

7 Combination

The panel recommended any future connectivity impact analysis should seek to examine the suite of proposals as a package to fully estimate the overall effects of water access restrictions to improve connectivity

7.1 Panel's proposal

The Panel recommended any future connectivity impact analysis should seek to examine the suite of proposals as a package to fully estimate the overall and combined effects of water access restrictions to improve connectivity.

The panel has proposed 3 different types of flow targets to improve connectivity outcomes in the Barwon-Darling:

- a resumption of flow target to protect the first flows after a dry period and provide a small fresh all the way to Menindee
- an end of system flow target in tributary valleys to provide for baseflows in the Barwon-Darling in on-dry times
- a connectivity environmental water allowance to provide a for a replenishment flow in extended dry times to maintain connectivity for critical human and environmental needs.

The hydrologic model has assessed different approaches for achieving each of these flow targets.

The Panel's report noted that it was difficult to use the findings of analyses to understand how flow targets may work together when they are only modelled individually. To address this a combination scenario has been done which takes one of the different approaches of achieving each of the flow targets and models them together.

It should be noted that the combination scenario has been done to provide an illustration of how the flow targets may work together. The inclusion of an approach in the combined run, does not indicate any preference for progressing that approach over another.

7.2 Scenario description – what was modelled

To assess the combined recommendations of the panel, a scenario that includes a representation of each of key recommendations has been undertaken. The approaches included in the combined scenario and reason they were selected by Water Group for inclusion are:

- extended resumption of flow rule: selected as Panel recommended inclusion of these additional trigger sites
- end of system flow – translucency: selected as it has more even diversions impacts across the valleys than the high security accounts approach
- connectivity environmental water allowance – Bourke flow trigger: selected as it is the approach closest to the intent of the Panel's recommendation

Note that the Macquarie valley only has the resumption of flow rule applied.

It should be noted that the inclusion of these scenarios in the combined run does not indicate any preference for progressing that scenario over another.

7.2.1 Model configuration and assumptions

This scenario is a combination of the approaches described in sections 4, 5, and 6.

Similarly to the modelling for the extended resumption of flow rule described in section 4, several iterations of the model scenarios was undertaken to take into account the interaction between releases for the replenishment and end of system flows with the extended resumption of flow rule.

7.3 Modelling results

7.3.1 Long term average diversions

The modelling results in Table 30 show that long-term average diversions are significantly reduced across all tributary valleys due to the increased releases from storages to provide replenishment flows in drier periods. These impacts vary across the valleys in response to the variation in flow rates and timing along each of the rivers, with the Macquarie Valley only impacted slightly as only the extended resumption of flow rule has been applied.

A review of the gross change in diversions from base case shows that the proportional reduction in diversions across the three most affected valleys is similar, although the gross reduction varies from 37.4 GL/y in the Gwydir valley, to 18.3 GL/y for the Border Rivers.

Barwon-Darling diversions decrease however, this impact has been reduced due to additional inflows from the end of system flow targets and replenishment flows, which acts to offset the impacts from the changes to the resumption of flow rules and reduces the flow benefits shown. In reality, something like active management would need to be used to protect additional inflows to realise all of the flow benefits along the Barwon-Darling. This is something we are unable to directly model at present but could potentially estimate with further work.

Table 30. Combination: change in long-term average annual diversion (1895-2023). Includes absolute change (GL/y) and relative change (%) from the base case.

Valley	Base case	Combination	Absolute change	Relative change
	GL/y	GL/y	GL/y	%
Border Rivers	214.2	195.9	-18.3	-8.5%
Gwydir	446.2	408.8	-37.4	-8.4%
Namoi	252.6	229.7	-22.9	-9.1%
Macquarie	330.2	327.6	-2.6	-0.8%
Barwon-Darling	171.3	167.8	-3.6	-2.1%

The combination scenario includes restrictions on supplementary and floodplain harvesting access, and also additional releases from major storages, which results in impacts on all categories of licences (Table 31).

For the Barwon-Darling River system, the additional inflows from tributary rivers that is not able to be protected in the model is offsetting some of the impacts to A/B/C Class licences, while floodplain harvesting licences remain impacted by the extended resumption of flow rule.

Table 31. Combination: change in long-term average annual diversions for each licence category (1895 – 2023). Includes absolute change (GL/y) and relative change (%) from the base case. Combination modelled the end of system - translucency, extended resumption of flow, and connectivity EWA – Bourke flow trigger being implemented together.

Valley	General security		Supp. or class A/B/C*		Floodplain harvesting	
	GL/y	%	GL/y	%	GL/y	%
Border Rivers	-10.0	-10.7%	-6.0	-8.5%	-2.3	-4.6%
Gwydir	-12.7	-6.1%	-16.4	-17.5%	-8.3	-6.3%
Namoi	-11.2	-8.3%	-4.8	-13.1%	-7.0	-8.9%
Macquarie	+0.7	+0.3%	-1.6	-12%	-1.7	-3.1%
Barwon-Darling	-	-	-2.0	-1.4%	-1.6	-5.0%

*Supplementary (supp.) access occurs in the Border Rivers, Gwydir, Namoi and Macquarie valleys. Class A/B/C access occurs in the Barwon-Darling.

7.3.2 Annual diversions

The impacts on water users vary across years, with impacts occurring in most years. In some years, the modelled diversions can increase from the base case scenario, as restrictions to access in one year can (for example) lead to more airspace in on-farm storages to take water in the following year. To show the variability of impacts across all years of the model run, the annual diversions for each valley are shown in Figure 34 to Figure 38, with the base case diversions and the changes to these that are modelled in this scenario.

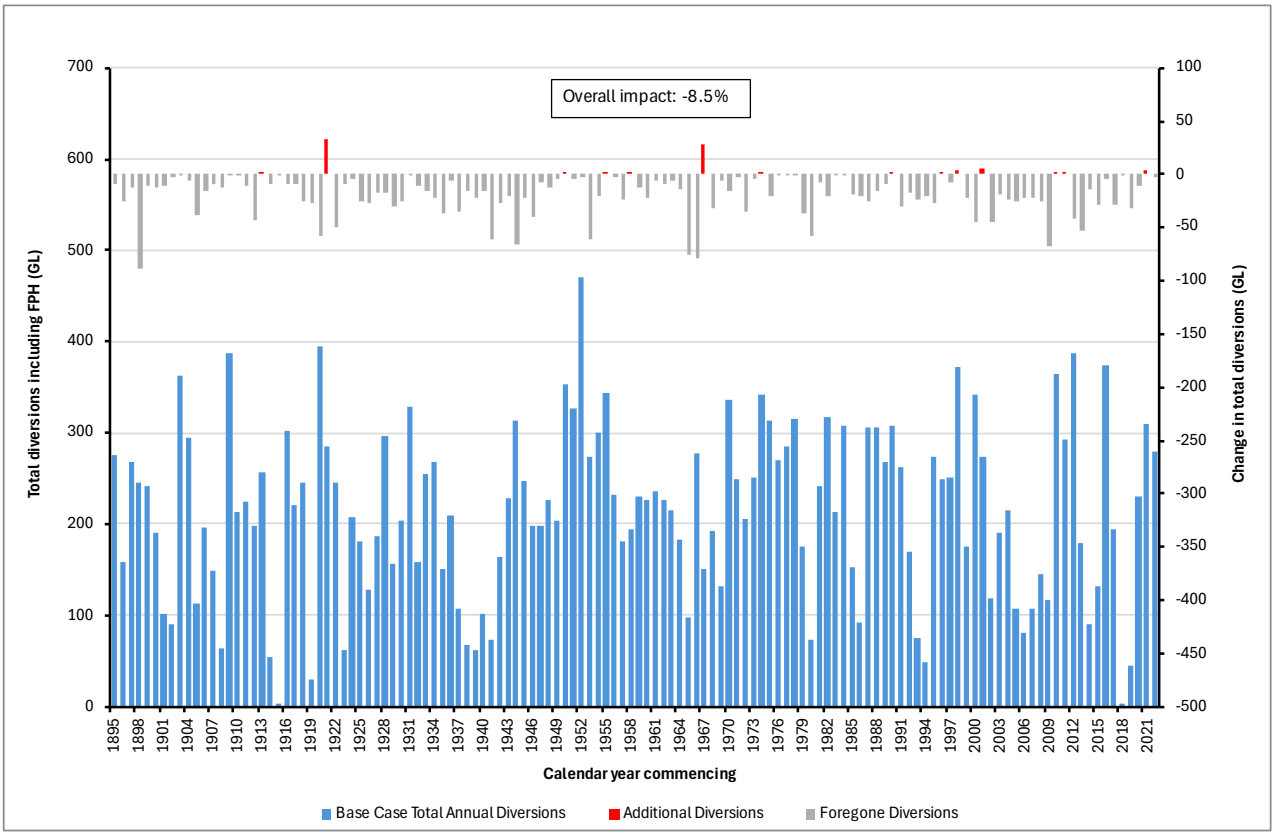

Figure 34. NSW Border Rivers annual base case diversions and changes arising from the combination scenario (1895-2023)

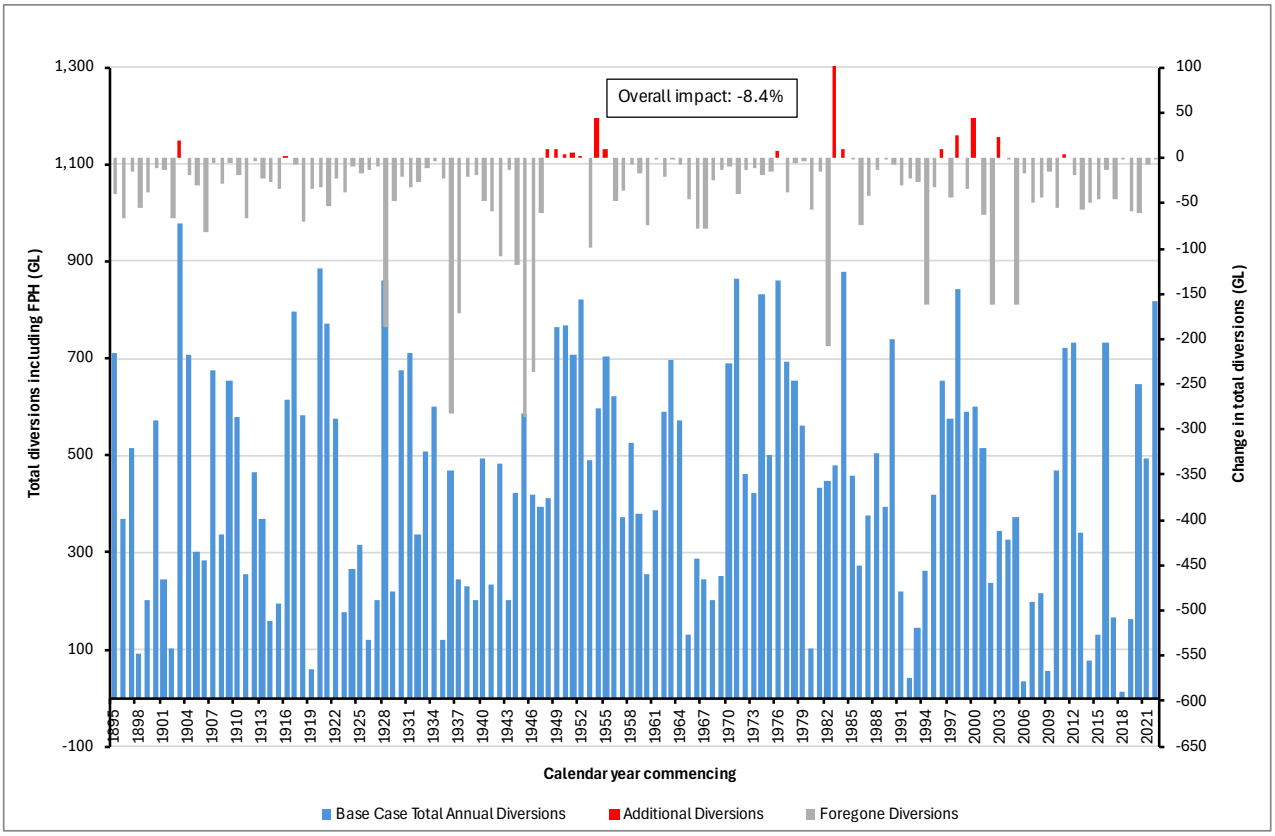

Figure 35. Gwydir Rivers annual base case diversions and changes arising from the combination scenario (1895-2023)

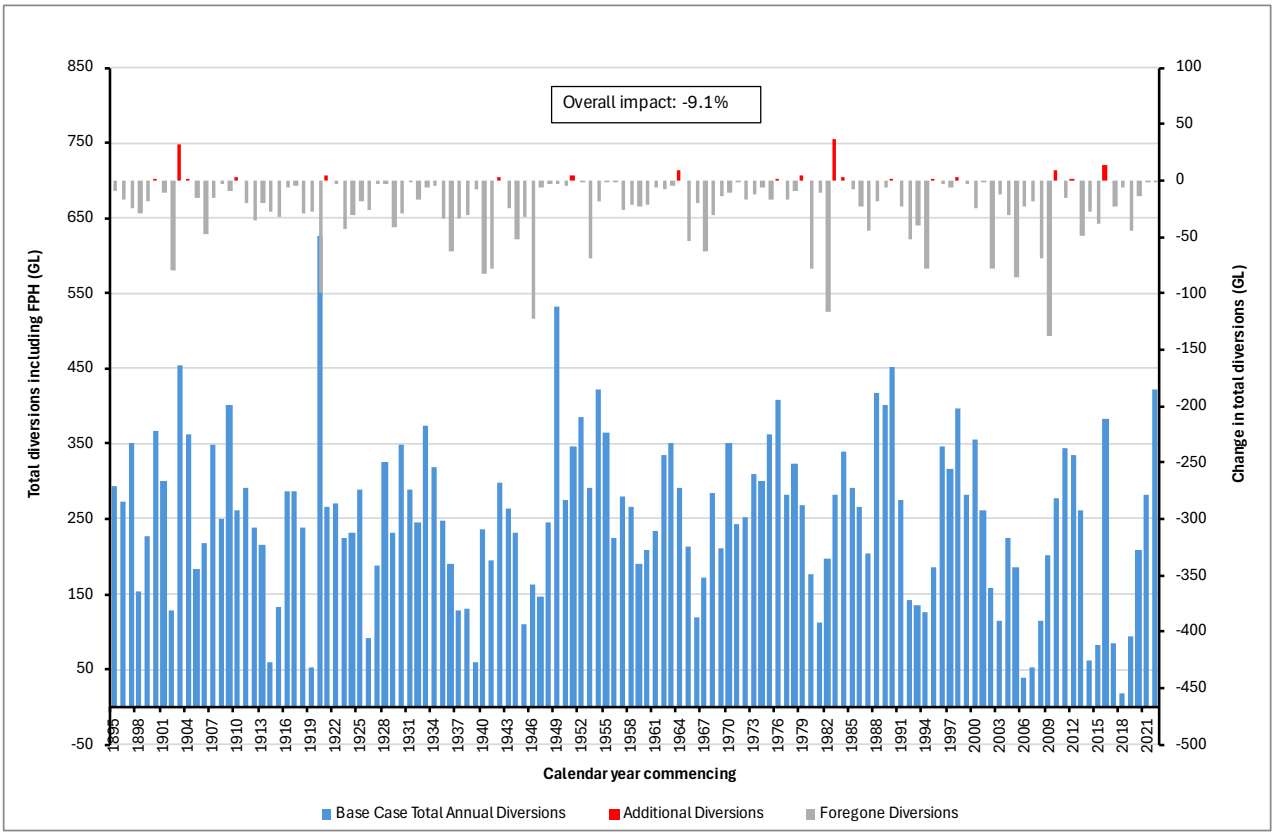

Figure 36. Namoi annual base case diversions and changes arising from the combination scenario (1895-2023)

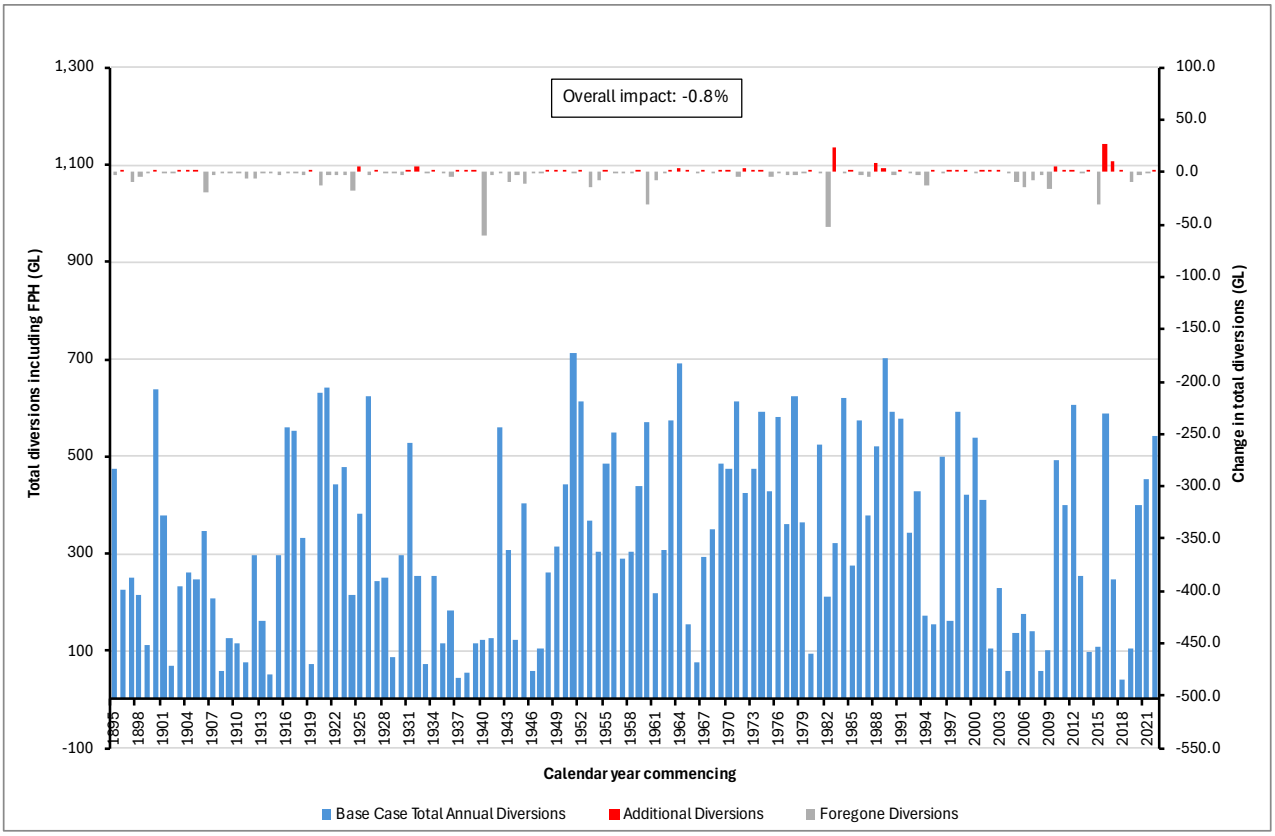

Figure 37. Macquarie annual base case diversions and changes arising from the combination scenario (1895-2023)

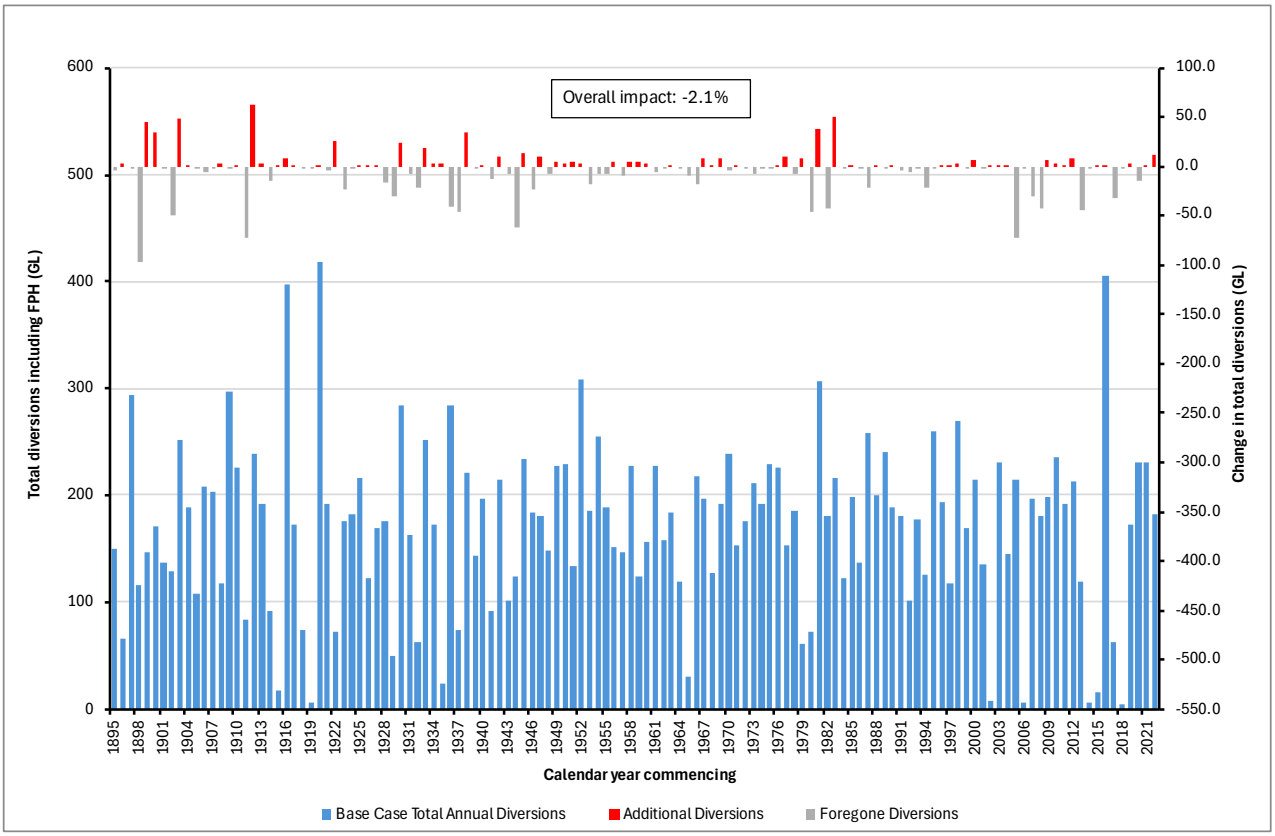

Figure 38. Barwon-Darling annual base case diversions and changes arising from the combination scenario (1895-2023)

8 Menindee Lakes trigger restrictions with Panel's resumption of flow

The Panel's report included recommendations in relation to management of Menindee Lakes and recommended that once these recommendations are implemented further analysis be undertaken on whether a trigger for refilling the upper Lakes is warranted.

The Panel outlined in their report that the volume of water in Menindee Lakes is not a good indicator of whether the northern Basin is entering a critically dry period. However, they acknowledge the role of the Lakes in providing critical human health and environmental needs and maintain connectivity in the lower Darling-Baaka. The Panel's report included a number of recommendations on changing the management and operations of Menindee Lakes to improve risk management for the Lower Darling-Baaka. Any changes to the rules or operation of the Lakes and related agreements, would require negotiation and support from the Basin Officials Committee and the Murray-Darling Basin Ministerial Advisory Council.

The Panel recommended that once the Government has determined which of the Panel's rules are intended to be implemented and the likely contribution of those rules, as well as any changes to held environmental water, further analysis should be undertaken regarding the potential need for any additional flows into the Menindee Lakes.

Each of the scenarios modelled in the previous sections increased flows at Wilcannia and would result in higher inflows to Menindee Lakes. Section 9 of this report provides an assessment of how each of the modelled scenarios may change the volume of water available in Menindee Lakes. It is worth noting that the Barwon-Darling IQQM tends to over-simulate low flows, which can also affect modelling of Menindee Lakes storages in the Source Murray Model.

Temporary water restrictions have previously been implemented when Menindee Lakes fall to critically flow levels to protect the first flows of water from extraction and refill the upper Lakes to a level needed to supply critical needs and maintain connectivity in the lower Darling-Baaka.

This scenario was modelled to assess if restrictions in addition to the extended resumption of flow would improve the volumes of water in the upper Lakes during and coming out of drought periods.

8.1 Scenario description – what was modelled

Access restrictions based on Menindee volumes have been added to the extended resumption of flow (Panel triggers) described in Section 4.

The additional restrictions to supplementary, floodplain harvesting, and Barwon-Darling A/B/C Class access commence when the active volume in the top two lakes at Menindee (Wetherell and Pamamaroo) falls below 250 GL (55% of their active storage capacity). Two options for lifting restrictions were tested:

- 310 GL lifting trigger: restrictions cease when active volume in top lakes rises above 310 GL. This equates to triggers in Western Regional Water strategy, if Pamamaroo Inlet is not repaired), which 68% of the active storage capacity in the top lakes
- 400 GL lifting trigger: restrictions cease when active volume in top lakes rises above 400 GL. This is 88% of the active storage capacity in the top lakes.

8.1.1 Model configuration and assumptions

Menindee restriction triggers use the active volume in lakes Wetherell and Pamamaroo, which are the upper two lakes in the Menindee lakes system (referred to as the top lakes). This includes the connected smaller lakes known as Lake Tandure (connected to Lake Wetherell), and Copi Hollow (connected to Lake Pamamaroo).

To assess the required restrictions based on storage volumes in Menindee Lakes, the modelled outflows from the Barwon-Darling IQQM base case were used as inflows into the Source Murray Model which models the Menindee Lakes storages. The Source Murray Model configured to represent current conditions by the Murray-Darling Basin Authority (the model custodian) was used as the base case model for this assessment. This model simulates the current operation of Menindee Lakes, including the preferential use of the lower lakes (Lakes Menindee and Cawndilla) to meet downstream demands ahead of drawing on the top two lakes.

The restrictions have been applied to upstream rivers when the active storage in the top lakes first fall below 250 GL and are similarly lifted when the active storage in the top lakes exceeds the lifting threshold (310 GL or 400 GL), without any allowances made for travel times.

The various valley models operate separately and are not able to pass information between each other during the model simulations. To provide restrictions for the upstream valleys, the period of restrictions based on Menindee storage volumes was initially calculated for the base case and applied to all valleys. The imposition of these restrictions will generate additional flows into the Menindee Lakes and shorten the period of restrictions that is required.

To reflect this interaction between the models, the initial results from the tributary and Barwon-Darling models have been input into the Source Murray Model, and the restriction periods have been re-derived. An iteration of the modelling was undertaken, with these re-derived restriction periods applied to the upstream models, and the results then input again to the Source Murray Model. The results from the final iteration of the models have been presented in this report.

8.1.2 Modelling results

Periods of restrictions

The periods of restriction from extended resumption of flow rule, the Menindee 250/310 and 250/400 restrictions triggers, and the periods where both extend resumption of flow and Menindee triggers occur are shown in Table 32 and Table 33.

The tables show that:

- the Menindee trigger restrictions occur more often than the resumption of flow rule restrictions in the lower sections of the Barwon-Darling

- in the upper sections of the Barwon-Darling and tributary valleys the time in restrictions is distributed more evenly across the extended resumption of flow and the Menindee 250/310 triggers (Table 32)
- the Menindee 250/400, with its higher with the higher volumetric trigger at Menindee for lifting restrictions, dominates the restriction periods in all sections (Table 33).

The high volumetric thresholds at Menindee Lakes for placing and lifting restrictions are resulting in restrictions occurring for a large proportion of the time. Overall, there are slightly more periods of restriction in the upper reaches of the Barwon-Darling and the regulated tributaries, with the total time in restriction varying from 41% - 44% in the upper reaches to 35% - 36% in the lower reaches for Menindee 250/310 restriction triggers. For the Menindee 250/400 restriction triggers, there are more restrictions, and the geographic differences are less pronounced.

Table 32. Proportion of time in restrictions from extended resumption of flow rule (Panel trigger sites) and Menindee 250/310 trigger restrictions (1895 – 2023)

	Mungindi (Border)	Collaren-ebri (Gwydir)	Walgett (Namoi)	Brewarrina (Macquarie)	Bourke	Louth	Wilcannia
Only Menindee 250/310 restrictions	18%	14%	16%	17%	21%	21%	26%
Only extended RoF restrictions	11%	13%	11%	9%	5%	4%	3%
Both restrictions at the same time	14%	17%	15%	15%	11%	11%	5%
Total proportion of time in restrictions	43%	44%	42%	41%	36%	36%	35%

Table 33. Proportion of time in restrictions from extended resumption of flow rule (Panel trigger sites) and Menindee 250/400 trigger restrictions (1895 – 2023)

	Mungindi (Border)	Collaren-bri (Gwydir)	Walgett (Namoi)	Brewarrina (Macquarie)	Bourke	Louth	Wilcannia
Only Menindee 250/400 restrictions	31%	27%	30%	30%	32%	33%	37%
Only extended RoF restrictions	5%	8%	6%	6%	4%	3%	2%
Both restrictions at the same time	10%	13%	11%	11%	8%	8%	3%
Total proportion of time in restrictions	46%	48%	47%	46%	44%	44%	42%

8.1.3 Long term average diversions

The modelling results in Table 34 and Table 35 show that long-term average diversions are reduced across all tributary valleys by the Menindee volume trigger compared to the extended resumption of flow described in Section 4.3. These impacts vary across the valleys with the underlying levels of water use by supplementary access and Barwon-Darling Class A/B/C licences.

For Menindee 250/310 restrictions, a review of the absolute change in diversions from base case shows that the reduction in diversions across the Border (23.9 GL/y) and Namoi (24.8 GL/y) valleys is similar, with the Gwydir valley (49.3 GL/y) having the largest reduction (Table 34).

A similar situation occurs under the Menindee 250/400 restrictions, with the absolute change in diversions from base case showing a similar reduction in diversions across the Border (28 GL/y) and Namoi (29.1 GL/y) valleys, and the Gwydir valley (57.4 GL/y) having the largest reduction (Table 35).

The larger volumetric impacts in the Gwydir valley is not reflected in the percentage impact due to the Gwydir valley long-term average diversions being approximately twice that of the Namoi and Border Rivers.

Table 34. Extended resumption of flow plus Menindee 250/310 restrictions. Change in long-term average annual diversion (1895-2023). Includes absolute change (GL/y) and relative change (%) from the base case.

Valley	Base case	Extended RoF + Menindee 250/310	Absolute change	Relative change
	GL/y	GL/y	GL/y	%
Border Rivers	214.2	190.3	-23.9	-11.2%
Gwydir	446.2	396.9	-49.3	-11.1%
Namoi	252.6	227.8	-24.8	-9.8%
Macquarie	330.2	324.1	-6.1	-1.9%
Barwon-Darling	171.3	150.3	-21.1	-12.3%

Table 35. Extended resumption of flow plus Menindee 250/400restrictions: change in long-term average annual diversion (1895-2023). Includes absolute change (GL/y) and relative change (%) from the base case.

Valley	Base case	Extended RoF + Menindee 400/310	Absolute change	Relative change
	GL/y	GL/y	GL/y	%
Border Rivers	214.2	186.2	-28.0	-13.1%
Gwydir	446.2	388.8	-57.4	-12.9%
Namoi	252.6	223.5	-29.1	-11.5%
Macquarie	330.2	322.2	-8.0	-2.4%
Barwon-Darling	171.3	144.2	-27.2	-15.8%

The changes in long term average diversions for each licence category are shown in Table 36 and Table 37, indicating that large impacts occur to supplementary access and Barwon-Darling Class A/B/C access across the valleys due to the extensive periods of restrictions that occur. Conversely, there are small increases in general security water use as the modelled water users rely more heavily on general security access.

Table 36. Extended resumption of flow rule plus Menindee 250/310 restrictions: change in long-term average annual diversions for each licence category (1895 – 2023). Includes absolute change (GL/y) and relative change (%) from the base case.

Valley	General security		Supp. or class A/B/C*		Floodplain harvesting	
	GL/y	%	GL/y	%	GL/y	%
Border Rivers	+6.4	+6.9%	-22.9	-32.4%	-7.4	-15.0%
Gwydir	+2.1	+1.0%	-32.5	-34.9%	-18.9	-14.3%
Namoi	+2.5	+1.9%	-10.9	-29.9%	-16.5	-21.1%
Macquarie	+1.3	+0.5%	-3.8	-28.1%	-3.6	-6.6%
Barwon-Darling	-	-	-16.6	-11.9%	-4.5	-14.1%

*Supplementary (supp.) access occurs in the Border Rivers, Gwydir, Namoi and Macquarie valleys. Class A/B/C access occurs in the Barwon-Darling.

Table 37. Extended resumption of flow rule plus Menindee 250/400 restrictions: change in long-term average annual diversions for each licence category (1895 – 2023). Includes absolute change (GL/y) and relative change (%) from the base case.

Valley	General security		Supp. or class A/B/C*		Floodplain harvesting	
	GL/y	%	GL/y	%	GL/y	%
Border Rivers	+7.2	+7.8%	-25.9	-36.6%	-9.3	-18.8%
Gwydir	+2.1	+1.0%	-37.3	-40.0%	-22.2	-16.9%
Namoi	+3.3	+2.4%	-13.3	-36.5%	-19.1	-24.4%
Macquarie	+2.5	+1.1%	-4.9	-36.3%	-5.6	-10.3%
Barwon-Darling	-	-	-21.3	-15.3%	-5.8	-18.1%

*Supplementary (supp.) access occurs in the Border Rivers, Gwydir, Namoi and Macquarie valleys. Class A/B/C access occurs in the Barwon-Darling.

9 Modelled changes in Menindee Lakes

The panel recommended that any environmental water from implementing their proposed flow targets should be protected through to Menindee Lakes. Once protected flows reach Menindee Lakes the water should be held as an environmental water allowance for use in supplying critical environmental needs for the lower Darling-Baaka River or released as translucency flows and protected through the Lower Darling River.

9.1 What was modelled

Each of the scenarios modelled in the previous sections increased flows at Wilcannia and would result in higher inflows to Menindee Lakes. However, there may still be a gap a between the additional inflows and volumes needed to supply critical human health and environmental needs and maintain connectivity in the lower Darling-Baaka.

It should be noted that the Menindee Lakes are a shared resource. Potential changes to the rules or operation of the lakes and related agreements, including protection of additional inflows, would require negotiation and support from the Basin Officials Committee and the Murray-Darling Basin Ministerial Advisory Council.

Modelling has been undertaken to assess the change in the Menindee Lakes volumes from the implementation of the potential connectivity rules modelled. The approaches that have been assessed include:

- extended resumption of flow
- end of system – high security account
- end of system - translucency
- connectivity EWA - dam inflow trigger[37]
- combination: models together the extended resumption of flow, end of system - translucency approach and connectivity EWA – Bourke flow trigger
- extended resumption of flow plus Menindee 250/310
- extended resumption of flow plus Menindee 250/400.

9.1.1 Model configurations and assumptions

To assess the improvement in storage volumes in Menindee Lakes arising from each scenario, the modelled outflows from the Barwon-Darling IQQM were used as inflows into the Source Murray Model, which models the Menindee Lakes storages. A Source Murray Mode configured to represent

[37] Change in Menindee inflows from the connectivity EWA Bourke flow trigger was not assessed due to time constraints.

current conditions by the Murray-Darling Basin Authority (the model custodian) was used as the base case model for this assessment. There is currently no representation of active management in the Barwon-Darling IQQM and, for this initial modelling assessment, there is no protection of the additional flows into Menindee Lakes for environmental use in the Lower Darling.

9.1.2 Model results

The figures below show the modelled total Menindee Lakes storage volume (Figure 39 and Figure 40) and upper Menindee Lakes storage volume (Figure 41 and Figure 42). The figures indicate that:

- there would be some improvements in the volume of water in storage, even at higher storage levels.
- there are most improvements in storage volumes under the extended resumption of flow with Menindee trigger restrictions (Figure 40 and Figure 42 which focus on higher exceedances/drier conditions)
- of the approaches that don't include a Menindee trigger, there are generally more improvements in storage volume in the upper Lakes under the combination scenario, although the difference is smaller at the very high exceedance levels (driest conditions) and other scenarios can provide slightly more improvement at times (Figure 41 and Figure 42)

The absence of a process to protect the additional flows into the Barwon-Darling River means that these results will likely under-estimate the improvements in storage volumes in Menindee-Lakes for some scenarios.

- focusing on higher exceedances (drier conditions) in Lakes Wetherell and Pamamaroo that are important for supply to the Lower Darling River during drought periods (Figure 42) shows that not including restrictions based on Menindee Lakes:
  - there are most improvements in storage volumes under the combination scenario, although the difference is smaller at the very high exceedance levels (driest conditions) and other scenarios can provide slightly more improvement at times
  - the combination scenario, with the largest improvement, would result in the active storage in the upper lakes exceeding 250 GL approximately 5% of the time more than in the base case, with all other scenarios falling between these.

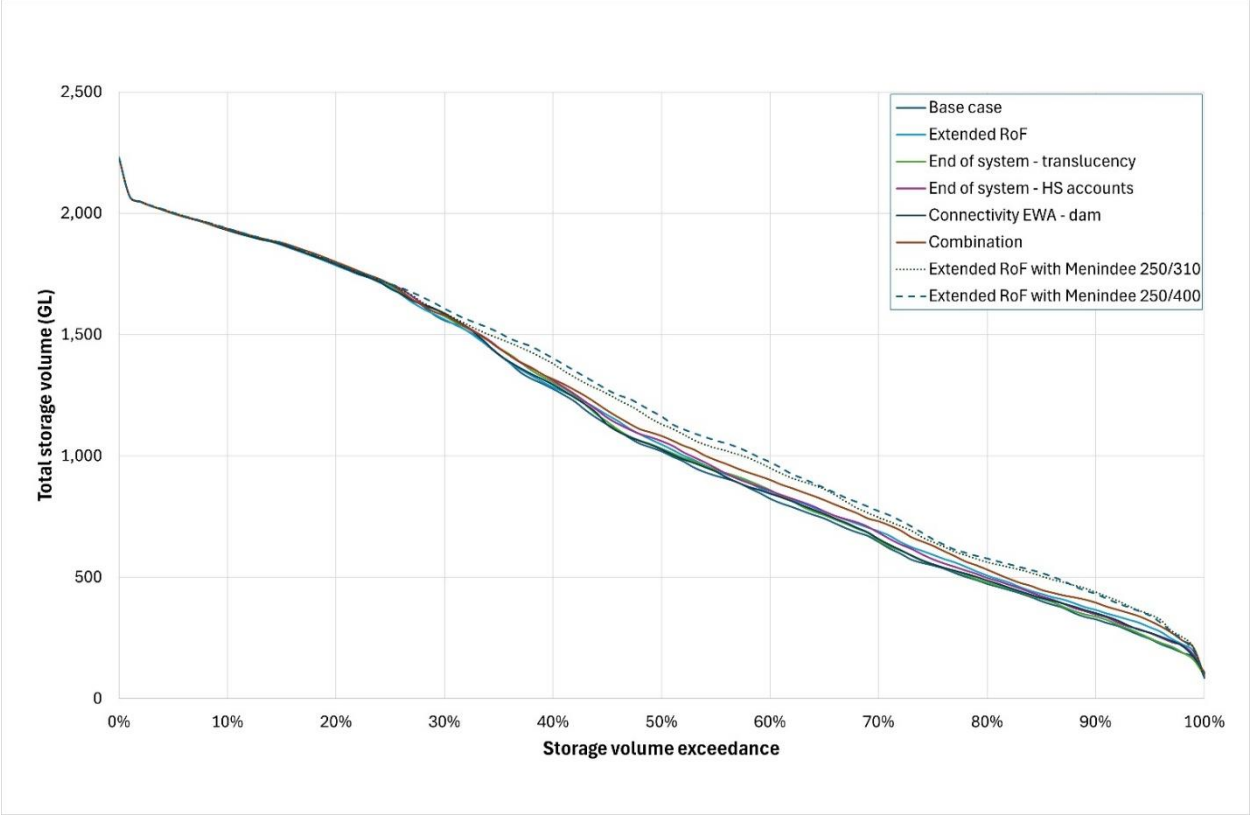

Figure 39. Total lakes storage volume exceedance (proportion of time the storage is higher than a volume)

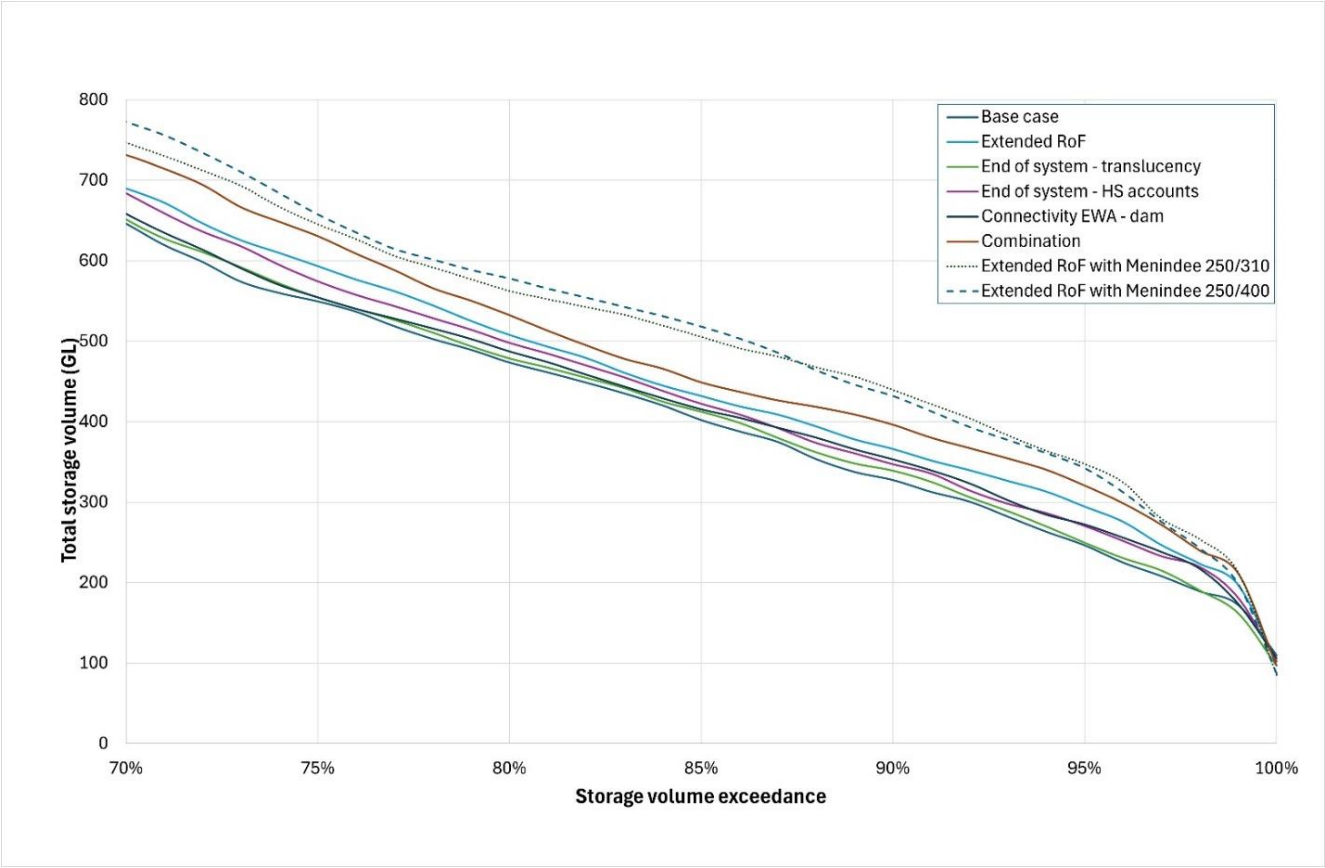

Figure 40. Total lakes storage volume exceedance (proportion of time the storage is higher than a volume) – focus on drier exceedance conditions

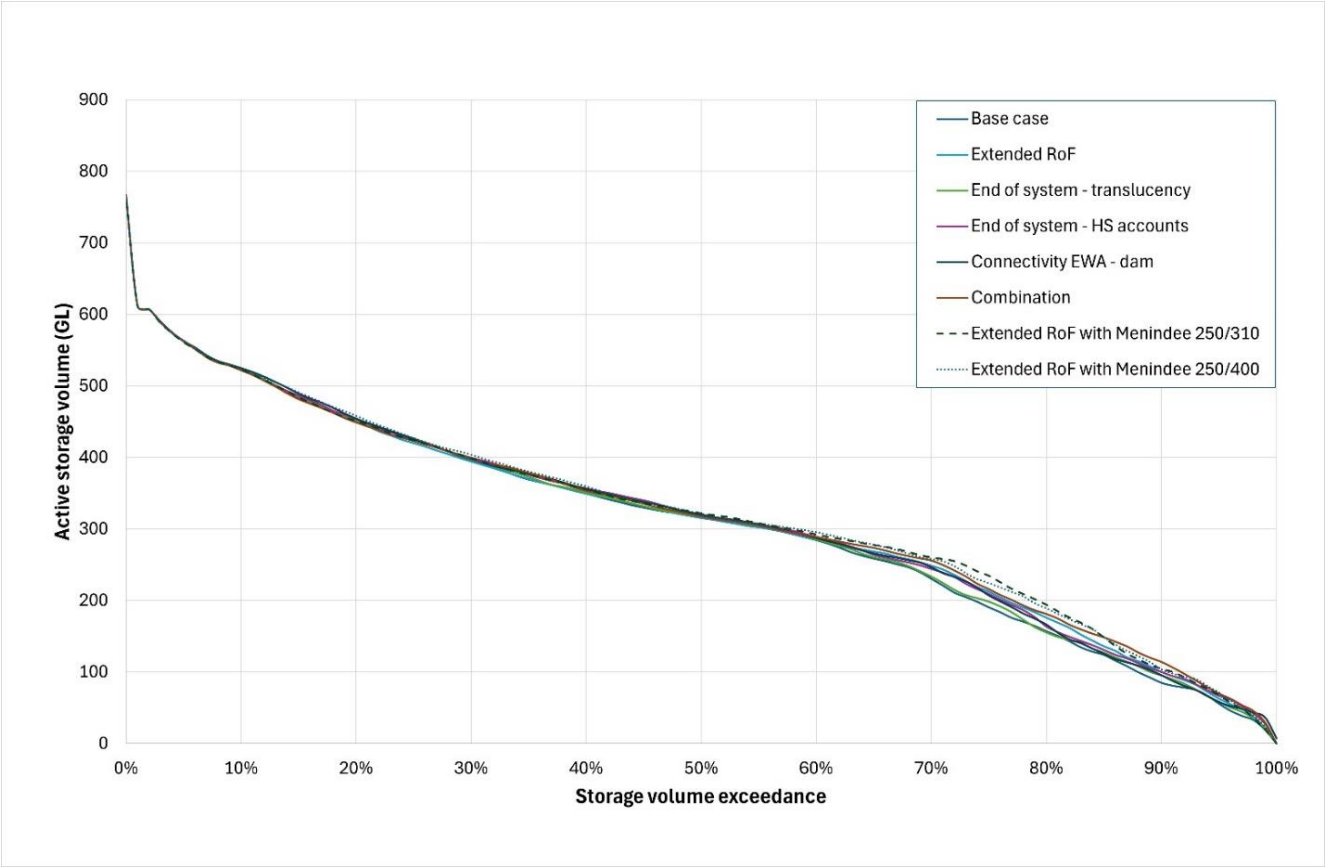

Figure 41. Upper lakes (Wetherell and Pamamaroo) storage volume exceedance (proportion of time the storage is higher than a volume)

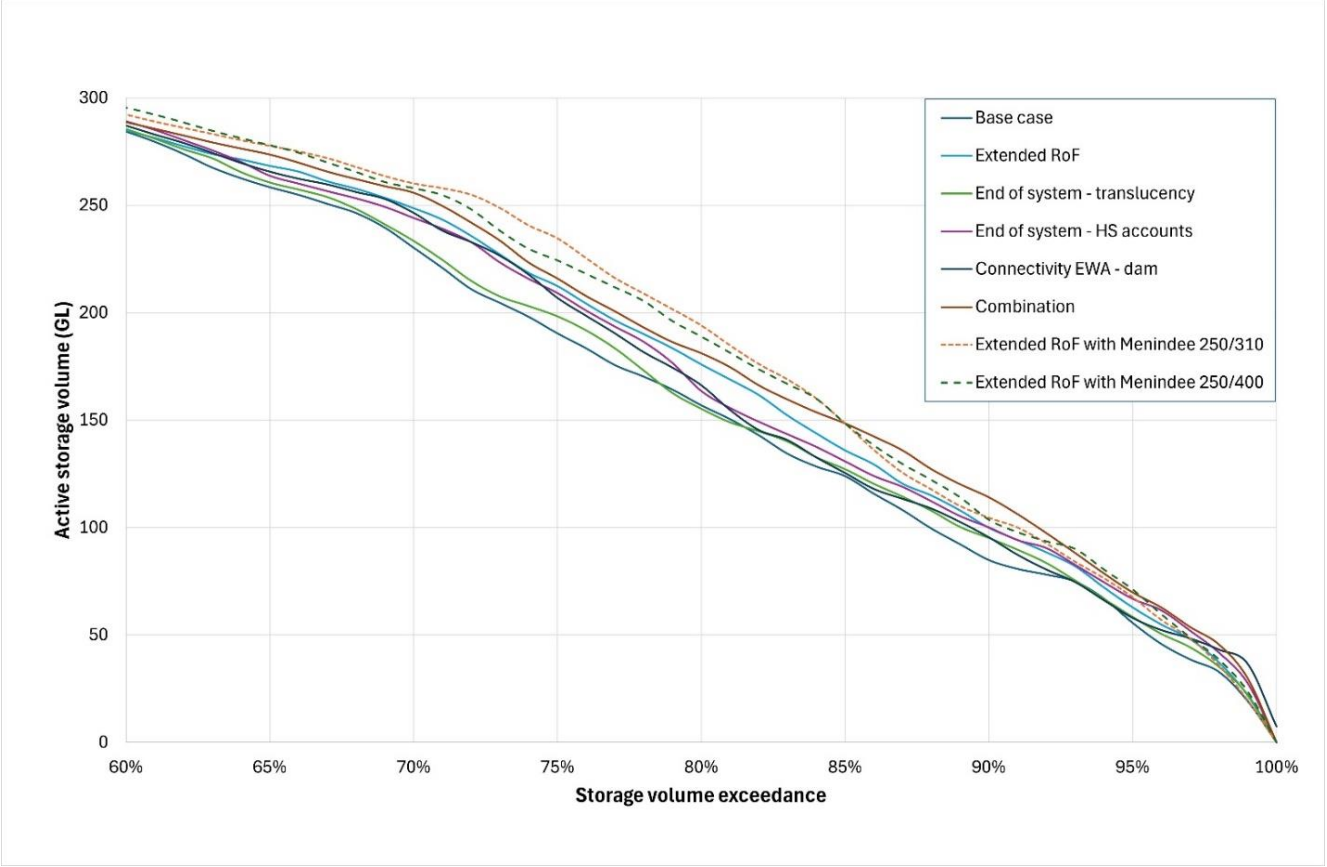

Figure 42. Upper lakes (Wetherell and Pamamaroo) storage volume exceedance (proportion of time the storage is higher than a volume) – focus on drier exceedance conditions

The impact of each approach on the combined Lake Wetherell and Lake Pamamaroo (upper lakes) storage volumes during the most recent drought are shown in Figure 43. This shows that none provides a significant overall improvement in storage volumes in the upper lakes during this period, although there are small improvements from the scenarios with replenishment releases.

While some approaches provide some improvements to the volumes of water in Menindee Lakes they would not maintain storage volumes above critically low levels during severe drought periods.

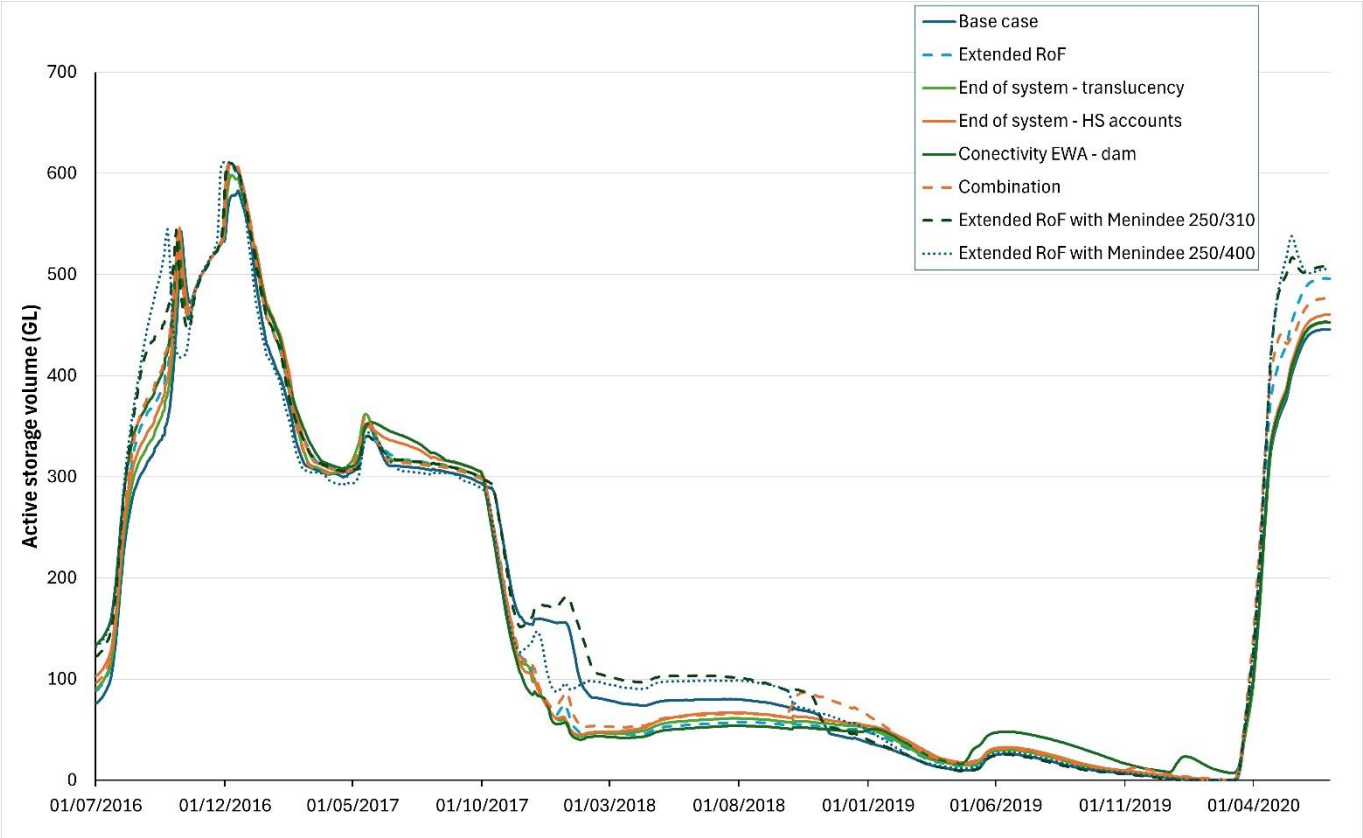

Figure 43: Modelled active storage volumes in the upper lakes (Wetherell and Pamamaroo) from 2016 to 2020

Appendix A – summary of targets and triggers proposed by the Panel

Table i-a Summary of Panel's recommendations – connectivity targets and triggers for non-dry times

Non-Dry times		
Proposal	**Proposed in-valley targets**	**To meet proposed targets in the Barwon-Darling**
Protection of baseflow *Regulated water sharing plans should have an end of system flow requirement to enable baseflow targets in the Barwon-Darling to be achieved during non-dry times. This should be achieved through limitations on supplementary and floodplain harvesting access in the first instance, with releases made from storage if these flows are not adequate.*	• Mungindi (416001): 160 ML/d • Walgett - Namoi River at U/S Walgett (419091): 30 ML/d • Collarenebri - Mehi Near Collarenebri (418055): 40 ML/d • Galloway (416052): 25 ML/d	• Mungindi (416001): 160 ML/d • Collarenebri - Barwon River at Collarenebri (422003): 280 ML/d • Walgett- Dangar Bridge (422001): 320 ML/d • Bourke (425003): 500 ML/d • Wilcannia (425008): 350 ML/d
Proposal	**Proposed Targets**	**Additional details**
Protection of small freshes *Regulated water sharing plans should include restrictions on supplementary and floodplain harvesting, and A, B and C licences in the Barwon-Darling to achieve annual small fresh flows. Restrictions should apply even if targets will not be fully met.*	• Mungindi (416001): 540 ML/d • Collarenebri (422003): 650 ML/d • Walgett (419091): 700 ML/d • Bourke (425003) 1,550 ML/d • Wilcannia (425008): 1,400 ML/d	A minimum of 14 days between September and April every year. (Note this covers both SF1 and SF2 targets in the Barwon-Darling Long Term Water Plan). 14 days must be targeted. However, if an event is targeted with restrictions and the small fresh flow is only achieved for 10 days or more it will be considered as met for that period. Restrictions begin at the start of September until the target is achieved, if a small fresh has not been achieved in the previous 12 months.

Non-Dry times		
Proposal	**Proposed in-valley targets**	**To meet proposed targets in the Barwon-Darling**
Protect large freshes *Regulated water sharing plans should include restrictions on supplementary and floodplain harvesting, and B and C class licences in the Barwon-Darling to achieve periodic large fresh flows.*	• Mungindi (416001) 3,000 ML/d • Collarenebri (422003): 4,200 ML/d • Walgett (419091): 6,500 ML/d • Bourke (425003): 15,000 ML/d • Wilcannia (425008): 14,000 ML/d	15 days minimum at least once every 2 years. Anytime, but ideally July to September. 15 days must be targeted. However, if an event is targeted with restrictions and the large fresh flow is only achieved for 10 days or more, it will be considered as met for that period. Starting in July restrictions begin if a large fresh has not been achieved in the previous 24 months and the operator forecasts that flows are likely to achieve at least 85% of the large fresh targets.

Table i-b Summary of Panel's recommendations – connectivity targets and triggers for transition periods

Transition arrangements	
Proposal	**Description**
Commence transition to new resumption of flow rules *When the system begins to enter a 'dry' stage, there will be a transition to 'dry' time resumption of flow rules which are triggered when flows drop below baseflow for a certain duration at various locations throughout the system.*	When the inflows to the major dams in the individual tributary drops below the 75th percentile on average over a 30 day period, then releases from dams to achieve end of system flows are suspended in that tributary. Once flows in the Barwon-Darling drop below baseflows, the resumption of flow rule 90-day count would begin. The Panel recommends further sensitivity analysis of the specific trigger[38] . Note: There will be a transition period between when releases to achieve the end of system flow rule are suspended and when the resumption of flow rule restrictions are triggered. During this period the end of system minimum flow rule would still apply to uncontrolled flows. This restriction should apply even if the uncontrolled flows will not fully meet the targets as any contribution to flows downstream at this point is very beneficial for the ecosystems.

[38] The Panel based the selection of the trigger on analysis on historic inflows to the dam and a general principle that when inflows to the dam are no longer supporting the end of system flow, then the releases should be suspended. We recommend that the Department consider further sensitivity analysis to maximise achievement of targeted outcomes while minimising impacts.

Table i-c Summary of Panel's recommendations – connectivity targets and triggers for dry times

Dry Times		
Proposal	**Proposed trigger**	**Proposed lifting target**
Revise the resumption of flow rules *The resumption of flow rules should be applied in the northern tributaries as well as the Barwon-Darling. The trigger for lifting restrictions should be raised to a forecasted small fresh all the way down the system to ensure flows through to Wilcannia and into Menindee Lakes.* Note: The end of system flow rule would still apply to uncontrolled flows during this time but releases from the dam would not be made	• Mungindi: <160 ML/d for 90 days • Collarenebri: <280 ML/d for 90 days • Walgett (Dangar Bridge): <320 ML/d for 90 days • Brewarrina: <550 ML/d for 90 days • Bourke: <500 ML/d for 90 days • Louth: <450 ML/d for 90 days • Wilcannia: <350 ML/d for 90 days	• 540 ML/d for 14 consecutive days forecast to be met • 650 ML/d for 14 consecutive days forecast to be met • 700 ML/d for 14 consecutive days forecast to be met • 1,000 ML/d for 14 consecutive days forecast to be met • 1,550 ML/d for 14 consecutive days forecast to be met • 1,500 ML/d for 14 consecutive days forecast to be met • 1,400 ML/d for 14 consecutive days forecast to be met

Table i-d Summary of Panel's recommendations – connectivity targets and triggers for all times

All times	
Proposal	**Description**
Menindee Lakes trigger	Chapter 6 [of the Panel's report] outlines the Panel's recommendations in regard to Menindee Lakes. The Panel recommends that once these recommendations have been implemented, further analysis be undertaken on whether a trigger for refilling upper Menindee Lakes is warranted. Any trigger should be based on addressing the specific risk that is being targeted and supported by analysis of whether the trigger is likely to achieve the intended outcome.
Establish 'Connectivity' environmental water allowance: *The Gwydir, Namoi and Border Rivers regulated water sharing plans should include a 'connectivity' EWA to provide pulses as needed for water quality and other environmental outcomes during dry times. This should be managed by DCCEEW Biodiversity, Conservation and Science to achieve connectivity objectives.*	Further analysis required: The Panel is of the view that the Connectivity EWA should at a minimum provide for reconnecting pools for critical human water needs, environmental needs and water quality needs during severe dry times. The Department's proposed critical dry condition triggers provide a basis for the flows that would be necessary to achieve this. Given time constraints, the Panel was unable to fully investigate this option. Further steps necessary to assess this option are provided in Section 4.5.2 of the Panel's report. Note: The 'connectivity' EWA should have the highest security status and therefore take precedence in the dam storage so that it can be used when it's required.
Update rules in unregulated water sharing plans	For non-dry times • Implement cease to pump rules in unregulated water sources identified as important for contributing to connectivity downstream and align rules in water sources adjacent to the Barwon-Darling with the rules in the Barwon-Darling for consistency and equity. • Implement active management where necessary to protect water that is protected for environmental or connectivity purposes in the regulated system and flows into the unregulated system. • Implement restrictions on unregulated water sources when restrictions are triggered in the regulated water sharing plans by the resumption of flow rule, or to achieve a small or large fresh.

All times	
Proposal	**Description**
	For dry times • Unregulated users in plans identified as important for contributing to connectivity downstream should be restricted from accessing water while the resumption of flow rule restrictions are in place.