Draft Western Regional Water Strategy

Attachment E: Critical dry condition triggers to reduce risk to environmental and human water needs Discussion Paper

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Cover image Image courtesy of Destination NSW. Menindee Lakes, Menindee.

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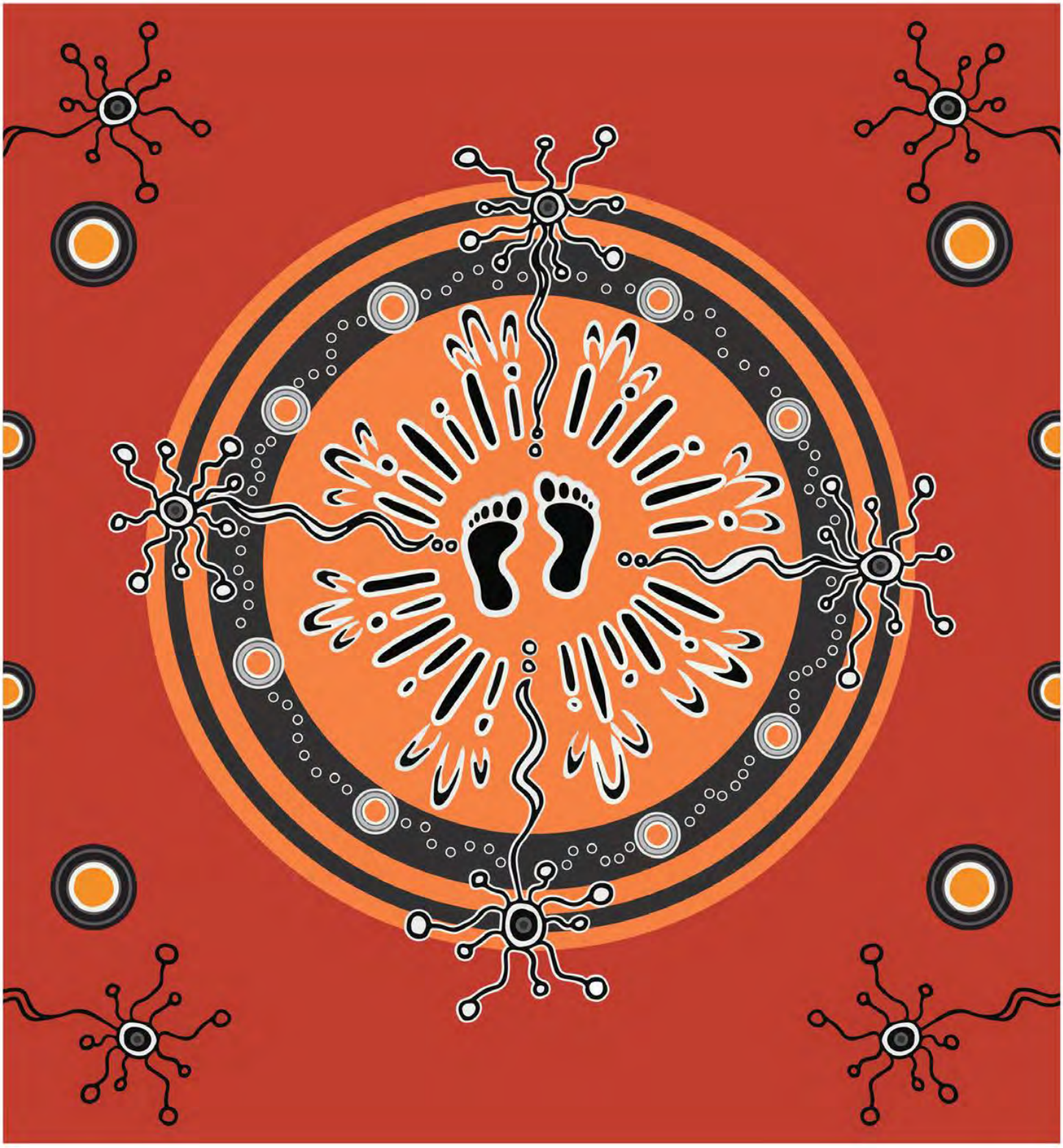


Acknowledgement of Country

The Department of Planning and Environment acknowledges that it stands on Aboriginal land. We acknowledge the Traditional Custodians of the land and we show our respect for Elders past, present and emerging through thoughtful and collaborative approaches to our work, seeking to demonstrate our ongoing commitment to providing places in which Aboriginal people are included socially, culturally and economically.

Purpose of this paper

The Water Group within the NSW Department of Planning and Environment has developed draft triggers designed to reduce the risk of critical water shortages leading to severe damage to water-dependent environments and failure of surface water supply for towns and landholders. The triggers are a signal that management action should be undertaken to reduce the risks.

In the northern Murray–Darling Basin, which includes the Barwon–Darling River above the Menindee Lakes, these triggers will initiate temporary water restrictions under section 324 (s324) of the *Water Management Act 2000*.

The paper aligns with several recommendations in the Independent Panel Assessment of the Management of the 2020 Northern Basin First Flush Event such as:

- ensuring the evidence base and methodology for first flush management is quantified, science-based and made publicly available, including estimated requirements to meet critical water needs (Recommendation 3)
- publishing guidance material which outlines how temporary water restrictions to manage first flush events will be used (Recommendation 5)
- making any temporary water restrictions required to manage first flush events on a proactive basis (that is, before rain is forecast) to enhance the ability of water users and communities to plan their activities and minimise any potential adverse effects of restrictions (Recommendation 6)
- is some of the foundational work to progress embedding the management of first flush events in the regulatory and policy framework for managing drought (Recommendation 7).

Importantly, this paper is not about actions to address river connectivity across a range of flows but, rather, to protect flows during extreme dry times and the first flows after an extended dry period. The Draft Western Regional Water Strategy outlines broader connectivity options and suggests a range of tools to manage water needs and system-scale connectivity in the long-term.

We are seeking feedback on the draft dry condition triggers that have been developed. This paper provides background information on why the triggers were developed and why different types of triggers were chosen in different locations. We have also highlighted where interim triggers are proposed while we research alternative approaches.

Image courtesy of Destination NSW. Murray and Darling Junction, Wentworth.

The draft triggers at a glance

Temporary water restrictions in the northern Murray–Darling Basin

Temporary water restrictions on some commercial access can be issued under section 324 (s324) of the *Water Management Act 2000* across the northern NSW Murray–Darling Basin in response to prolonged dry conditions. The triggers outlined in Table 1 would initiate a s324 to protect subsequent flows until the lifting triggers have been met. This is a proactive approach to s324 implementation to protect flows during extreme conditions. These triggers are drafted as a starting point for consultation.

Image courtesy of Department of Planning and Environment – Environment and Heritage. Western Floodplain, Toorale.

Table 1. Proposed triggers that could initiate/lift temporary water restrictions in the northern Murray–Darling Basin

Location for proposed trigger	Proposed trigger for implementing temporary water restrictions	Proposed trigger for lifting temporary water restrictions
Wilcannia	When there is a high confidence forecast cease-to-flow period of 120 days at Wilcannia (20 ML/day at Darling River at Wilcannia 425008).	400 ML/day for 10 days (or 4,000 ML) is forecast.
Bourke	When there is a high confidence forecast cease-to-flow for 60 days (0 ML/day at Darling River at Bourke 425003).	972 ML/day for 10 days (or 9,720 ML) is forecast.
Menindee Lakes storage[1]	Forecast to fall below 195 GL capacity.	If releases have ceased below the Menindee Lakes, restrictions would not be lifted until the Lakes were forecast to have enough water to provide up to 12 months supply for human needs and allow the river to be restarted in a way that reduces the risk to water quality issues downstream and fish deaths. This will depend on conditions at the time and any operating constraints. For example: • if the Lower Darling River hasn't ceased to flow, triggers could be lifted once the Lakes are above 195 GL • if the Lower Darling River has ceased to flow, additional water above the 195 GL such as 60 GL may be required to restart the river[2] • if evaporation rates are extreme and operational constraints require water to be held in inefficient lakes, more water will be required in the Lakes before the restrictions can be lifted. The trigger for lifting restrictions may need further refinement following consultation.
Northern valleys and Barwon–Darling River system.	Classified as Drought Stage 4 criticality under the department's drought stages, and/or Cease-to-flow for 30 days (or more extended periods following feedback from consultation) at any of these sites.	Resumption of flow targets for each of the northern tributaries such as:
• Border Rivers – Macintyre at Goondiwindi (416201A)		• 3,600 ML over 7 days
• Gwydir River – Mehi at Moree (418002)		• 3,600 ML over 7 days
• Macquarie – below Warren Weir (421004)		• 21,000 ML over 7 days
• Namoi – below Mollee Weir (419039).		• 8,000 ML over 7 days.

1. Where Menindee Lakes storage has the same meaning as it does under the Murray–Darling Basin Agreement
2. A 60 GL Lower Darling River flow restart allowance has been proposed to be included in the water sharing plan for the Lower Darling

The proposed triggers for implementing and lifting restrictions are based on an assessment of critical needs. The cease-to-flow periods at Wilcannia and Bourke are based on work completed by the MDBA (2018). These may be revised while research is undertaken on other options that would use live information during a dry period. Such an approach, which might use satellite images of refuge pools and weirs along the Barwon–Darling River, would help us to develop triggers that are based on the severity of drought conditions at the time.

The Menindee Lakes target reflects the storage volume required to provide critical needs for the Lower Darling for up to 12 months. The Lakes also provide refuge for fish and wildlife during dry conditions, so maintaining this target volume also provides environmental benefits.

Under the Department's definitions, Drought Stage 4 is declared in a regulated river system and the Barwon–Darling River if remaining supplies are only sufficient to meet essential town and other limited high priority needs. The 30-day cease-to-flow periods are proposed for the northern tributaries, as an example of possible indicators of drought conditions. We will continue to develop the northern Basin triggers proposed in Table 1. This will include review of the proposed trigger locations and cease-to-flow durations.

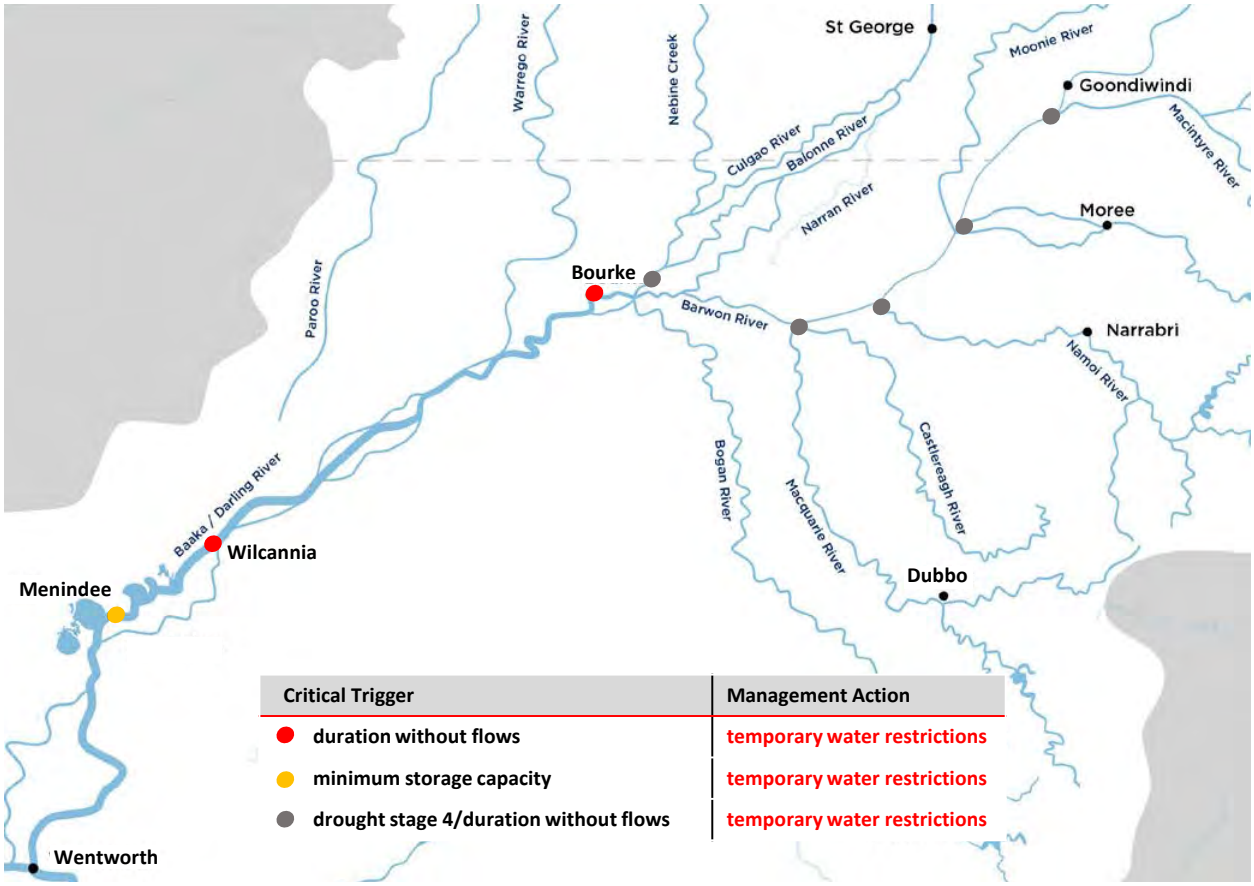
Approaching these triggers would signal when upstream restrictions on lower priority access (floodplain harvesting, supplementary, large high flow unregulated river licence holders and Barwon–Darling A, B and C class licence holders) would need to be imposed. Imposing restrictions on other water licence classes such as general security will be considered during the event, depending on conditions and the extent of restrictions already in place.[3]

The lifting triggers are based on the flow, or storage level in the case of Menindee Lakes, to replenish supplies, following a dry period. If releases have ceased below the Lakes, restrictions would not be lifted until the Lakes were forecast to have enough water to provide up to 12 months supply for human needs (taking account of evaporation losses) and create an additional volume of 60 GL that could be used to safely restart the Lower Darling River. This 60 GL restart allowance is currently being proposed for the *NSW Murray and Lower Darling Regulated Rivers Water Sharing Plan*.

Lake Wetherell has a lower evaporation rate than the other lakes in the system because it is deeper and narrower. That is why it is the preferred storage during dry conditions. However, operational constraints can require WaterNSW to store water across multiple lakes. When this is necessary, water loss due to evaporation is increased substantially. As a result, the predicted evaporation offset in the lakes changes depending on which lakes have to be used for dry condition storage.

An overview of the location of the proposed triggers is shown in Figure 1.

Figure 1. Location of draft trigger sites for the Barwon–Darling River and Menindee Lakes background



3. During the First Flush protections in early 2020, most general security account water was already suspended.

Background

The Barwon–Darling River has a naturally variable flow regime with regularly occurring low flow and cease-to-flow periods. However, between 2017 and early 2020, northern inland NSW experienced record drought conditions that severely impacted water availability for human and environmental needs. The drought broke in the first months of 2020 when significant rain fell in the northern Murray–Darling Basin.

From 17 January 2020 to 28 February 2020, the (then) Department of Planning, Industry and Environment restricted commercial water access in the northern Basin to the flows generated by this rain by issuing temporary water restriction (s324) orders. The protected flows reconnected the Barwon–Darling River through to the Menindee Lakes and enabled a restart of releases from the Lower Darling River to Wentworth. Thousands of kilometres of rivers across the northern Basin and Lower Darling flowed for the first time in many months. Prior to this, the Menindee Lakes hadn't released water since January 2019 and the Barwon–Darling River upstream had become a series of disconnected pools.

The 2020 northern flow event marked the first time that temporary water restrictions had been applied across such a large area and range of types of commercial water extraction (i.e. general security, high security, unregulated river, floodplain harvesting and supplementary access). The restrictions were lifted progressively as flows passed, or were forecast to pass, to meet specific targets set along the rivers and for Menindee Lakes.

The department has produced several reports and assessments to evaluate the effectiveness of the 2020 event.[4]

An independent panel was appointed by the Minister to review the event and provide recommendations on future temporary water restrictions. The panel published its findings in the Independent Panel Assessment of the Management of the 2020 Northern Basin First Flush Event.[5]

Key recommendations for the department were to:

- develop a clear definition and quantification of critical water needs during dry conditions
- develop clear triggers that will determine when first-flush management arrangements start and when they cease to apply (reverting to water sharing rules)
- ensure that the methods for first-flush management are evidence-based, scientific and made publicly available.

Temporary water restrictions and priorities under the Water Management Act

The NSW *Water Management Act 2000* sets out the general priorities for access to water. This involves promoting the protection of the water source and its dependent ecosystems as well as basic landholder rights to water.

During severe water shortages, the focus shifts towards securing critical domestic water needs. When managing extractions at these times, domestic needs for essential town services and individual landholders are considered first followed by the needs of the environment. Water for stock and high-security access licences are the next highest priority.

In addition to these priorities, s324 of the Act allows temporary water restrictions to be implemented if it is in the public interest, such as:

- to cope with water shortages
- where there are threats to public health and safety
- to protect flows for environmental purposes.

Temporary water restrictions are intended to meet needs or circumstances that fall outside of the normal water sharing plan rules and are not 'business as usual' instruments.

Image courtesy of Daniel Coleman. An isolated refuge pool near Tilpa on the Darling River during the drought in March 2018.

4. Available from the north-west flows in early 2020 pages of the department's website: www.industry.nsw.gov.au/water/allocations-availability/northern-basin-first-flush-assessment
5. www.industry.nsw.gov.au/water/allocations-availability/droughts-floods/drought-update/managing-drought-recovery/north-west-flows-in-early-2020

What we mean by critical dry conditions

Critical dry conditions for the environment

Dry periods occur naturally in the Murray–Darling Basin. During extended dry periods, water in refuge pools evaporates and the pools contract. Large pools fragment into smaller pools and become crowded with wildlife, leading to increased predation and a build-up of toxic waste including harmful blue-green algal blooms. Pools can become stratified, separating into layers of different temperatures and oxygen concentrations. The bottom layers can have too little oxygen for fish to survive.

The NSW Government has produced a fact sheet, Defining 'needs of the environment' during extended dry events,[6] setting out the legislative and policy background for protecting the environment during extreme dry periods. It outlines strategies that can be used to avoid loss of native species, communities and ecosystems, and prevent irretrievable damage that could prohibit ecosystems from recovering. Short-term, small-scale strategies include using aerators or relocation of stressed fish. Longer-term, large-scale strategies include coordinated protection of flow events to reconnect rivers and replenish pools.

Vertessy et al 2019, investigated the catastrophic fish deaths on the Darling River over the summer of 2018–19. The authors found that the events were most likely caused by a rapid cool change that led to surface water mixing with deoxygenated water at the bottom of the stratified pools. The mixing meant that oxygen levels would have crashed throughout the pool, leaving fish with nowhere to escape.

The authors also concluded that the pools had been in a critical and unstable condition (sitting at a tipping point) for several months beforehand. This meant that the fish deaths could have happened at any time over that period if the weather had changed sooner. Similarly, Baldwin 2019, discussed a wide range of interventions that could be used to reduce the impact of toxic water conditions, especially low oxygen and algal blooms, but none of these are as effective as refreshing stagnant water and preventing the conditions from reaching a tipping point.

We define critical dry conditions for the environment as the point when the risk of a catastrophic event has sharply escalated. Conditions that can signal this risk include where:

- evaporation has broken large refuge pools into smaller pools that can deteriorate at a faster rate than the larger pool
- dissolved oxygen levels and temperature vary significantly at different depths indicating that the pools are beginning to stratify. Oxygen levels at the bottom that begin to approach 2 to 3 mg/L can be lethal for many fish, forcing them to gulp for air at the surface (Ellis & Meredith 2004, Baldwin 2019)
- blue–green algal biovolume exceeds the 'amber alert' concentration of 4 mm^3/L and is approaching 10 mm^3/L, which is a 'red alert' concentration under the NSW *Public Health Act 2010*.

Image courtesy of Destination NSW. Menindee Lakes, Menindee.

6. Defining 'needs of the environment' during extended dry events: www.industry.nsw.gov.au/__data/assets/pdf_file/0005/288041/needs-of-the-environment-fact-sheet.pdf

Critical dry conditions for human water use

Towns along the Barwon–Darling are supplied by town weir pools. Weir pool conditions can deteriorate in the same way as natural pools, leading to problems with high salinity, blue–green algae or other toxins. Almost all Barwon–Darling and Lower Darling towns had to access groundwater during the recent drought and, at times, were largely or fully reliant on bore water because of insufficient and/or poor-quality surface water. With concerns about the quality of the bore water, bottled water was provided to some communities and water was also carted to several towns including Pooncarie and Menindee.

We define critical dry conditions for human water use as the point when the risk of insufficient water for high priority domestic supply for towns and individual landholders is escalated. Conditions that can signal this risk include where:

- the river has ceased flowing for a number of months
- evaporation has broken large weir pools into smaller pools that are harder to extract water from and can deteriorate at a faster rate
- conditions are approaching Stage 4 critical drought and town water use is subject to high levels of council restrictions, or there is a risk of towns running out of surface water within the next 3 months[7]
- blue–green algal biovolume has exceeded the 'amber alert' concentration of 4 mm^3/L and is approaching 10 mm^3/L, which is a 'red alert' concentration under the NSW *Public Health Act 2010.*

Image courtesy of Destination NSW. Sunrise at Menindee Lake, Menindee.

7. The 3-month threshold applies to small towns or towns under a certain population range. Things become very critical for large towns about 12 – 24 months away from running out of water.

Draft critical dry condition triggers

Extended dry periods can occur under hot or cool conditions. If a river has ceased to flow over autumn and winter, when weather conditions are relatively cool, it will take longer for isolated pools to reach critical conditions than it would during hotter months.

We have proposed draft triggers that allow water managers to respond with realistic options and timeframes. For example, temporary water restrictions can be effective for responding to critical dry conditions along the Barwon–Darling River or low storage levels in the Menindee Lakes. When a flow is forecast, management must allow for the possibility that it could take several weeks for a flow to arrive, especially if the rainfall is in the Queensland Basin valleys.

Proposed triggers for the Northern Basin and Barwon–Darling River to initiate temporary water restrictions

Critical environmental triggers

Alteration of the Barwon–Darling River's natural flow regime has affected the magnitude, frequency, duration and timing of all flows, but especially low flows and cease-to-flow periods (MDBA 2018, Mallen-Cooper and Zampatti 2020). NSW and federal agencies have identified maximum cease-to-flow periods in the Barwon–Darling in order to set the limit on what the environment can withstand without risking severe damage. These studies have guided the draft triggers for critical dry environmental conditions.

The Murray–Darling Basin Authority (MDBA) has recommended maximum cease-to-flow durations at Bourke and Wilcannia that are based on ecological 'thresholds of concern' (MDBA 2018). These were cease-to-flow durations that were outside the range of 'without development' flow models (models that estimated what flow conditions would be without human water extraction). The Authority considered that if recorded cease-to-flow durations were longer than those in the 'without development' model, then they would significantly increase the risk of environmental impacts.

The MDBA used flow data from 1990 to 2016 at 5 locations along the river but acknowledged that the Barwon–Darling hydrology models provide less accurate representations of low flow conditions than higher flows. In response, the report used other sources of evidence alongside flow models, including ecological studies, salinity management and blue–green algal management guidelines.

The Barwon–Darling Long Term Water Plan (LTWP) (Department of Planning, Industry and Environment –Environment, Energy and Science 2020a) also recommended maximum cease-to-flow durations between Mungindi and Wilcannia. These were based on analyses of modelled and historical flow records. Maximum cease-to-flow durations were based on the 95th percentile of recorded dry periods but flow data in the analyses was restricted to a period from 2000 to 2014 to maintain a consistent approach across all the planning units. This was necessary because many of the flow gauges on the Barwon–Darling River started operation in 1999.

We have used the MDBA 2018 maximum cease-to-flow durations to inform the draft triggers because they were derived from longer sequences of historical data than the LTWP recommendations and use additional lines of evidence. The proposed trigger for Wilcannia is 120 days of flows below 20 ML/day (the minimum flow that can be accurately measured at the gauge) and Bourke is 60 days below 0 ML/day (Table 2).

Disadvantages with using the MDBA 2018 triggers are that they are not available for other key locations such as Walgett and Brewarrina. Additionally, there is limited flexibility around climate and on-ground conditions, which may lead to the trigger durations being shorter or longer than appropriate. We are currently researching the practicality of developing triggers based on real-time remote monitoring of conditions in refuge pools. The current scope of this research will look at refuge pools on the Barwon–Darling between Mungindi and Lake Wetherell. Depending on the outcomes, the same approach could be applied to other valleys in time.

Table 2. Comparison of recommended maximum duration of cease-to-flow periods in the Barwon–Darling Long Term Water Plan (Department of Planning, Industry and Environment – Environment, Energy and Science 2020a) and 'Ecological needs of low flows in the Barwon–Darling: Technical Report' (MDBA 2018)

River section	Flow reference gauge	Maximum cease-to-flow duration (MDBA 2018)	Maximum cease-to-flow duration (Barwon–Darling LTWP 2020a)
Brewarrina to Bourke	Darling River at Bourke 425003	60 days of flows <1 ML/day	90 days
Bourke to Wilcannia	Darling River at Wilcannia 425008	120 days of flows <20 ML/day[8]	160 days

Flows have ceased at Wilcannia for prolonged periods dating back as far as 1926 when records are available. Table 3 lists periods of extended cease-to-flow at Wilcannia and highlights periods of 120 days or longer, noting that the frequency of these events has increased over the last 20 years.

Table 3. Cease-to-flow periods at Wilcannia (determined as less than 20 ML/day). Durations of longer than 120 days are highlighted in yellow, durations longer than 120 days with a brief intermission of low flows are highlighted in orange

Start	End	Days
28/12/1926	7/02/1927	42
30/08/1927	6/01/1928	130
11/12/1928	27/03/1929	107
4/02/1931	17/03/1931	42
31/03/1932	28/05/1932	59
4/01/1940	11/03/1940	68
7/09/1940	12/01/1941	128
10/12/1941	20/03/1942	101
5/06/1944	4/07/1944	30
22/12/1944	28/03/1945	97
22/12/1945	14/01/1946	24
20/08/1946	9/11/1946	82
21/12/1946	27/12/1946	7
29/12/1946	3/01/1947	6
7/11/1965	4/12/1965	28
12/12/1965	21/01/1966	41
5/01/1969	13/02/1969	40
13/09/1970	3/10/1970	21

Start	End	Days
19/11/1982	6/02/1983	80
24/11/1994	27/11/1994	4
7/12/1994	19/01/1995	44
30/11/1995	18/12/1995	19
19/10/2002	15/12/2002	58
26/01/2003	3/04/2003	68
23/10/2003	13/01/2004	83
15/09/2004	1/10/2004	17
6/01/2006	9/01/2006	4
16/10/2006	20/08/2007	309
26/09/2008	19/01/2009	116
7/11/2009	8/01/2010	63
21/12/2013	25/03/2014	95
1/11/2014	8/03/2015	128
9/01/2016	28/03/2016	80
29/01/2018	4/05/2018	96
24/10/2018	16/06/2019	236
22/09/2019	9/03/2020	170

8. WaterNSW has advised that 20 ML/day is considered to be a cease-to-flow measure because gauge 425008 Darling River at Wilcannia becomes unreliable below that flow rate.

Critical human water use triggers

Town weirs along the Barwon–Darling generally provide between 6 and 9 months supply for domestic needs and essential services. Bourke Weir, with a capacity of over 4,000 ML, provides around 6 months supply with no inflows and Wilcannia Weir (currently 3,000 ML capacity and proposed to be doubled in the upgrade to be commenced in late 2022) provides 4 to 5 months supply with no inflows.

The MDBA 2018, recommended that event-based management should be implemented to prevent no flow and very low flow periods at Wilcannia exceeding 120 to 150 days. A cease-to-flow period approaching or forecast to approach 120 days at Wilcannia (Table 2) has been considered as an appropriate trigger for restrictions.

The Barwon–Darling Water Sharing Plan recently introduced the resumption of flows (RoF) rule to protect low flows after an extended dry period in the Barwon–Darling. We investigated whether the RoF rule would be impacted by the proposed critical dry triggers, or whether operation of the RoF rule reduced the frequency or duration of cease-to-flow events in the Barwon–Darling. We found that the rule does not significantly influence the frequency and duration of extended cease-to-flow events, nor were there instances when the dry condition triggers were initiated without the RoF rule having already been activated. The rule only applies to water users covered by the Barwon–Darling Water Sharing Plan. We expect that the critical dry condition triggers will complement the resumption of flows rule by focussing on conditions that are outside the water sharing plan's intended rule, and by initiating management responses across the broader northern Basin.

Under the NSW Extreme Events Policy[9] (which sets out the framework for managing extreme events such as drought) a critical drought or water shortage is when the focus is on preserving water for essential town water and rural domestic demands only. This is classified as Drought Stage 4 Criticality. Drought Stage 3 Criticality occurs when high priority and general irrigation demands are restricted. Once a valley is in Drought Stage 4 Criticality, future inflows need to be protected for critical human and environmental needs. You can find more information on drought stages on the Drought stages and measures implemented during the 2017–20 drought page of the department's website.[10]

Over time, further work (using remote sensing) may be undertaken to investigate whether monitoring major weirs can identify a critical trigger point when human water supply is compromised. However, in the interim, we propose the following initial critical dry condition triggers for human needs:

- if Wilcannia is forecast to be without flows (<20 ML/day) for more than 120 days, or
- if Bourke is forecast to be without flows for more than 60 days, or
- Menindee Lakes fall below 195 GL capacity, or
- when the Barwon–Darling moves to Drought Stage 4 Criticality and/or when all or most of the northern Basin tributaries are classified as Drought Stage 4 criticality, and/or
- 30-day cease-to-flow northern valley triggers at:
  - Goondiwindi Weir (Macintyre River)
  - Yarraman-Moree (Gwydir River)
  - Warren Weir (Macquarie–Wambuul)
  - Mollee Weir (Namoi River).

The 30-day northern valley triggers are interim proposals while we continue to research the most appropriate trigger locations and durations, and may trigger implementing restrictions in the northern valleys separately from the Barwon–Darling and Menindee triggers. The northern valley triggers are designed to indicate serious dry conditions in these rivers where, in normal times, they would continue to flow. As mentioned above, a simpler alternative may be when the northern tributary valleys move into Drought Stage 4.

9. www.industry.nsw.gov.au/__data/assets/pdf_file/0008/187703/Extreme-Events-policy.pdf
10. www.industry.nsw.gov.au/water/allocations-availability/droughts-floods/drought-update/critical-valleys-in-drought

The Menindee Lakes critical storage level triggers

The Menindee Lakes are a naturally occurring series of shallow wetlands located along the Lower Darling River near the town of Menindee that were modified during the 1950s and 1960s to provide water storage for Broken Hill, users along the Lower Darling, and the southern Murray–Darling Basin. Broken Hill is no longer reliant on the Menindee Lakes as it is now supplied by a pipeline from the Murray River.

Water flows into the lakes system through Lake Wetherell, which is a ponded weir pool created by Menindee Main Weir on the Darling River. Other lakes in the system are filled sequentially once Lake Wetherell reaches a sufficient depth to connect either via natural sill levels (lakes Tandure, Balaka, Bijiji and Malta) or via regulator gates (lakes Pamamaroo, Menindee and Cawndilla). When the lakes are full or inflows have ceased, the lakes emptying sequence is the reverse of the filling sequence, meaning that Lake Wetherell is usually the preferred storage for holding water during extended dry periods and the source of flows into the Lower Darling. You can find more information about the lakes' operation in the MDBA's Menindee Lakes fact sheet.[11]

Flows in the Lower Darling during dry periods are entirely dependent on releases from the lakes. Reducing the risk of critical dry conditions is therefore dependent on adequate water being available in storage. With this in mind, we have proposed a critical storage trigger which is initiated when the total storage in Menindee Lakes falls below 195 GL. The 195 GL storage level is the result of modelling undertaken by WaterNSW that takes into account how the lakes operate, evaporation, and assumes zero inflows into Lake Wetherell. This volume can supply up to 12 months of water for human needs and minimum water sharing plan releases.

During extended drought conditions, Lake Wetherell is an important refuge because of its depth and volume. The Murray–Lower Darling Long Term Water Plan (Department of Planning and Environment – Environment and Heritage 2020b) and the MDBA (2012) recommend maintaining a minimum water level of 58.9 m AHD (Australian height datum), equivalent to 50 GL of storage, distributed between Lake Wetherell and Lake Tandure. The 58.9 m height supports drought refugia and fish survival by connecting pools, backwaters and fringing habitat in the 2 lakes (MDBA 2012, Baldwin 2020). If the majority of water is stored in Lake Wetherell, it may act as a refuge for fish and other aquatic organisms over the hottest period when evaporation rates are at their peak.

First flows for critical conditions in the Lower Darling

As stated earlier, flows in the Lower Darling during dry conditions are dependent on releases from the Menindee Lakes. The lower river has ceased to flow on several occasions and in the last 2 decades, we have learned important lessons about how best to deliver flows that mitigate the risks when releases are restarted. In 2004, a flushing flow inadvertently resulted in fish kills because discharge volumes were too low to mix oxygen through stagnant pools or safely move the accumulation of organic material downstream (Ellis & Meredith 2004, Baldwin 2021). Subsequent flushing events in 2016 and 2020 had higher flow rates and did not report any fish kills. You can find more information about the 2020 flushing flow in the information sheet Lower Darling release – water quality monitoring.[12]

We recommend maintaining the same strategy used for the 2020 flushing flow to restart flows. This was to:

- maintain a flushing peak at 3,000 ML/day at Weir 32 for 7 days
- gradually decrease flows down to 500 ML/day at Weir 32 after 21 days and then return to normal releases.

Based on this information we propose that, once the Lakes have fallen below 195 GL, and if releases have ceased below the Lakes, the restrictions remain in place until the combined lakes' storage is forecast to provide an additional 60 GL restart allowance and any extra storage, determined at the time, to compensate for any climatic or operational requirements to ensure up to 12 months supply can be retained.

Work is underway to include a Lower Darling River restart allowance of 60 GL in the next amendments to the Lower Darling water sharing plan. The allowance will apply whenever the total storage in the lakes falls below 480 GL. The first 60 GL of inflow to the Menindee Lakes that occurs after the Darling River at Weir 32 has ceased to flow for 10 consecutive days will be credited to the restart allowance. This can be used to restart the river through managed releases to minimise risks to water quality and aquatic species and may also be used to meet water orders along the Lower Darling. We will be examining how to integrate the operation of this allowance with trigger relaxation.

11. www.mdba.gov.au/publications/brochure/factsheet-menindee-lakes
12. www.industry.nsw.gov.au/__data/assets/pdf_file/0003/310629/summary-of-key-water-quality-findings.pdf

The proposed trigger of 195 GL is intended to provide critical human water needs for up to 12 months. We have also considered a draft trigger that would provide up to 2 summers, or 18 months, supply in Menindee Lakes under no inflows, but still with required water sharing plan releases which meet town, domestic and stock, and commercial needs. We did not progress this because significantly larger volumes of water would be required to be stored in lakes Pamamaroo and Copi Hollow that would also mean that a substantial amount of that water would be lost to evaporation.

The storage levels of Menindee Lakes over the last 30 years compared to a 195 GL storage trigger is shown in Figure 2.

Figure 2. Menindee Lakes storage, proposed triggers and cease-to-flow at Wilcannia

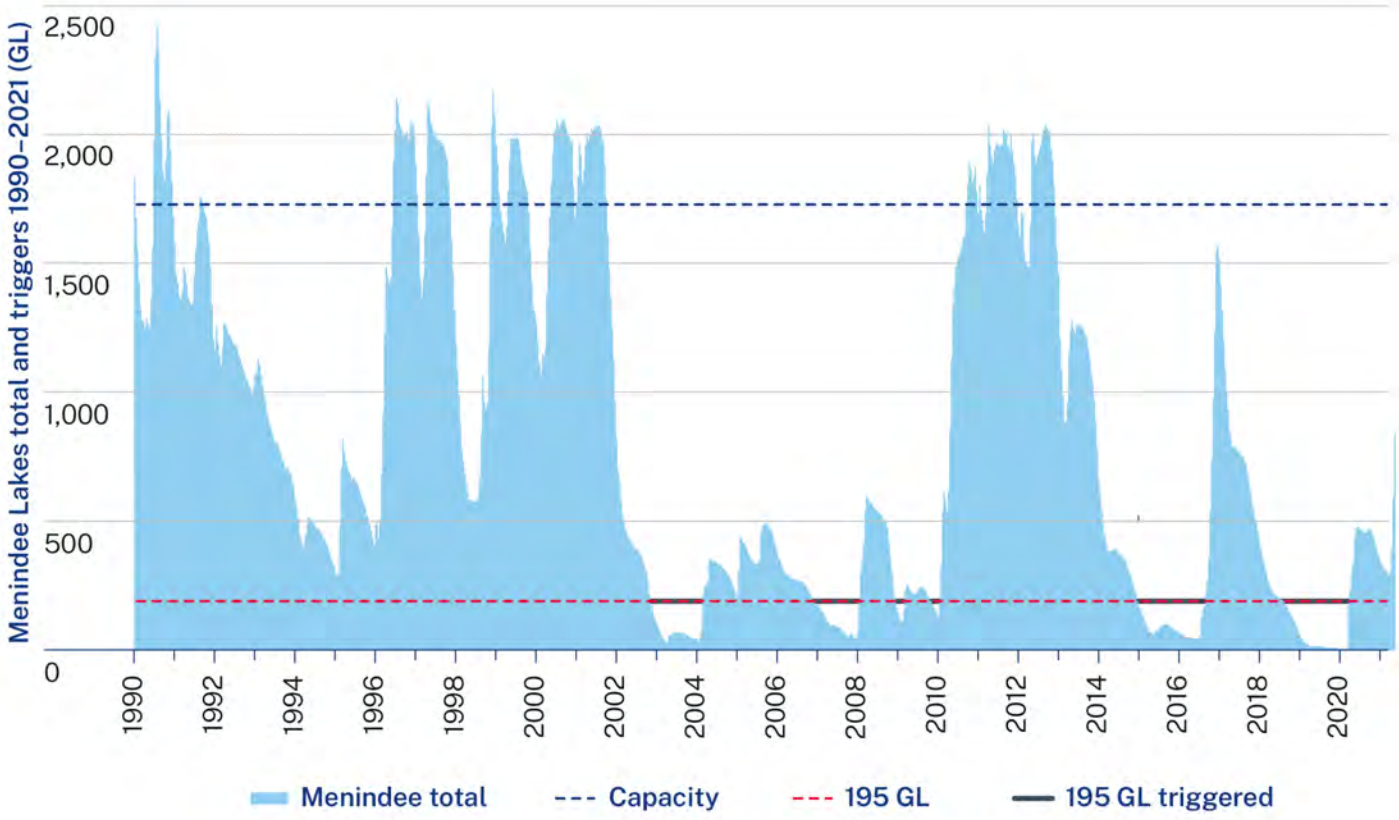


Figure 2 shows that the Lakes were below 195 GL 6 times since 2000:

- 5 November 2002 to 27 February 2004 – 479 days
- 24 November 2006 to 19 January 2008 – 421 days
- 11 December 2008 to 4 March 2009 – 83 days
- 29 October 2009 to 18 January 2010 – 81 days
- 23 December 2014 – 28 August 2016 – 614 days
- 4 August 2018 – 29 March 2020 – 603 days.

Cease-to-flow periods greater than 120 days at Wilcannia also correlate with the periods when the Menindee Lakes start to drop below 195 GL.

Image courtesy of Daniel Coleman. The Darling River upstream of Lake Wetherell after the restart of flows in March 2020.

Accounting for flow travel times to reach Barwon–Darling and Lake Wetherell trigger sites

Flushing flows will be most effective before or shortly after a refuge pool reaches the critical dry condition threshold. However, if temporary water restrictions are triggered at the time when the threshold is reached, there may be a considerable delay before flows actually arrive.

For example, the WaterNSW operations update for February 2020 showed that flows took about 50 days to travel from the end of the Border Rivers at Mungindi to Wilcannia (as detailed in the Operations Update February 2020 rainfall event).[13] On the other hand, rainfall in the lower Namoi or Condamine–Culgoa rivers may take as little as 14 to 18 days. During the 2020 northern Basin flow event, multiple flow events took place in different valleys. Both actual and forecast flows were carefully tracked and managed by the department and WaterNSW.

If our forecasting indicates that flows are unlikely to reach Bourke, Wilcannia or the Menindee Lakes before their critical dry condition triggers are initiated, then temporary restrictions may be announced earlier. Doing this will reduce the duration that these locations remain under critical conditions. Forecasting is not exact and will be heavily dependent on the conditions at the time, so the Department and WaterNSW will work together to develop a framework that will help to ensure decisions around forecast flow travel times can be predictable and clearly explained.

Research to develop remote monitoring of refuge pool extent and condition

The Department of Primary Industries – Fisheries (2015, 2020) and the Queensland Department of Science, Information Technology and Innovation (DSITI 2015) have extensively mapped natural pools and weir pools along the Barwon–Darling River. DSITI also used a combination of remote sensing and statistical modelling to estimate how long refuge pools could persist without flows in the lower Balonne and Barwon rivers. These approaches have the potential to be used for critical dry condition triggers, but more research is needed.

The department is undertaking a feasibility study to determine how readily the existing techniques can be applied to developing dry condition triggers on the Barwon–Darling River. We are investigating whether remote sensing data can be used to map how surface water contracts in refuge pools during droughts (Figure 3). Our aim is to identify the points when important refuge and water supply pools begin to fragment into smaller pools that are at greater risk of critical conditions. If this approach is feasible, we will develop a remote monitoring program that commences when flows cease at any one of the key locations of Brewarrina, Walgett, Bourke and Wilcannia. This program should be able to provide regular updates to the public as we continue to track conditions.

Figure 3. Satellite image of the Barwon–Darling River upstream of Brewarrina in February 2020. Blue indicates the presence of surface water. Orange is dry riverbed. Small orange patches indicate that large pools have fragmented into smaller pools due to evaporation

13. Operations Update February 2020 rainfall event: www.waternsw.com.au/__data/assets/pdf_file/0004/153814/Murray-ROSCCo-February-2020.pdf

Implementing and lifting temporary water restrictions

A, B and C class access in the Barwon–Darling, floodplain harvesting in the Barwon–Darling and in northern valleys, supplementary access in the northern tributaries and large unregulated river access on the lower northern valleys would be restricted when the triggers outlined above are forecast to be reached (see Table 1).

The proposed relaxation triggers at Wilcannia and Bourke (400 ML/day and 972 ML/day) are consistent with the triggers for lifting the RoF rule in the Barwon–Darling Water Sharing Plan. The RoF rule triggers are intended to provide water for basic landholder and town water needs, and baseflow environmental water requirements as defined in the 2018 Barwon–Darling Long Term Water Plan (version 5, now superseded).

The proposed northern valley relaxation triggers are based on previous experience with restarting the northern valleys. The trigger volumes are intended to provide a connecting flow through to the Barwon–Darling River while also replenishing weirs and refuge pools and meeting basic landholder and town requirements. Four locations have been selected in order to simplify the process of announcing and relaxing restrictions, but other locations and triggers will be looked at during this process.

If the northern tributaries are in Drought Stage 4 criticality and/or extended cease-to-flow periods have occurred (regardless of whether the Barwon–Darling and Menindee Lakes triggers are met), a section 324 restriction may be placed in these systems until flow recovers.

In the 2020 first flush event, the initial target for lifting restrictions in the Menindee Lakes during the 2020 event was 60–70 GL of additional inflows into an effectively empty storage. In practice, this target applied to the restrictions on access to all forms of licenced take in the northern valleys. With subsequent tributary inflows from Queensland, the target was increased to 200 GL. This helped deliver social, environmental and cultural outcomes for the Lower Darling and allowed a flushing flow to be sent down the river to improve the poor water quality and aquatic habitat before a return to more normal releases.

If a s324 restriction is implemented at Menindee Lakes because capacity drops below 195 GL, and releases have subsequently ceased, restrictions would be lifted once flows were forecast to reach Menindee Lakes and increase capacity to allow up to 12 months supply for critical needs, and an additional 60 GL to be released from the lakes as a re-start flush. Depending on operational constraints or whether evaporation conditions are particularly extreme, a greater volume may be required to ensure up to 12 months supply is protected. If releases have not ceased below the Lakes then the 60 GL may not be required to re-start the river and restrictions could be lifted sooner. This will depend on the conditions at that time and whether further inflows are expected.

However, if Menindee Lakes stays above 195 GL, but the Bourke or Wilcannia restriction triggers are forecast to be reached without an imminent flow event, then upstream restrictions would be implemented in both the Barwon–Darling and northern tributaries. The upstream restrictions would be lifted once a flow of 4,000 ML is forecast to reach Wilcannia (under most circumstance these flows would have passed through Bourke). This is consistent with critical human needs as defined by the Barwon–Darling Water Sharing Plan resumption of flow lifting target of 400 ML for 10 days. A flow of this size would also result in the filling of the existing Wilcannia town weir.

Lifting of restrictions would occur:

- progressively as flows move through the systems
- if there is high confidence in downstream flow predictions meeting targets even if access resumes
- in consideration of travel times and antecedent conditions that will impact on river losses.

Image courtesy of Destination NSW. Sun setting over the Darling River, Bourke.

Benefits of the restrictions

Regardless of the restrictions, there has been, and will continue to be, extended dry conditions in Menindee Lakes. As shown earlier in Figure 2, there have been a number of occasions in the last 20 years when the Lakes have been below 195 GL for long periods. Modelling shows that Menindee Lakes would also have fallen below 195 GL a number of times during the 1900s. During the Federation and World War 2 droughts Menindee Lakes would have been below 195 GL for similar periods to the millennium drought of between 300 and 400 days.

A low volume in the Menindee Lakes coincides with dry low flow periods in the northern tributaries. During a severe drought there may not be periods of inflows for some time. For example, during 2018 to 2019, there were no supplementary access periods in the northern valleys and B class pump thresholds in the Barwon–Darling were rarely met. However, some small inflows in the Barwon–Darling were embargoed to flow through the northern valleys and into the Menindee Lakes. Restrictions on accessing initial flows assisted in ensuring that flows extended downstream earlier than if pumping had been permitted.

An analysis of flows over the last 16 years shows that there is potential for some benefits to storage levels in Menindee Lakes from restricting B and C class and supplementary flow access. These benefits are generally through extending periods that Menindee Lakes are above the target level, rather than developing new periods. Modelling over the 119-year period from 1895 to 2014 shows that Menindee Lakes were above 195 GL around 94% of the time. Restricting floodplain harvesting, supplementary access and B and C class access improves Menindee Lakes staying above 195 GL to 97% of the time, depending on the extent and timing of restrictions.

Continued research and next steps

We are seeking feedback on all aspects of the initial draft triggers with the aim of finalising the triggers in mid-late 2022. When providing your feedback, remember that temporary water restrictions are intended to meet needs or circumstances that fall outside of the normal water sharing plan rules and are not 'business as usual' instruments. Specifying the triggers, and the rationale behind their development, is intended to provide some certainty to water users and the community about when restrictions will be implemented. Using s324 orders to implement these restrictions also allows us to refine the triggers as new information becomes available, and to assess the triggers in conjunction with the conditions during the dry period.

We heard from a range of different stakeholders that temporary water restrictions should not be relied upon as they do not provide certainty for water users, and they are at the discretion of government decision makers. Instead, most stakeholders prefer these types of restrictions to be implemented through water sharing plan rules. This could be done in future once the guidelines have been finalised. The Western Regional Water Strategy will also explore a range of connectivity options. If those options progress, it could negate or reduce the need for some of these temporary water restriction triggers.

We will continue working on remote sensing triggers for the Barwon–Darling River and will undertake more analysis and modelling to make sure that the draft triggers integrate well with other low flow protection rules. In particular, we will be closely examining how the critical dry condition triggers on the Barwon–Darling River interact with the resumption of flows rule in the Barwon–Darling Water Sharing Plan. We will continue working on the proposed northern valley cease-to-flow triggers where other locations will be considered and the interim durations refined.

Accounting for the predicted travel time of flow events is essential to making sure that critical condition triggers provide enough time for water managers to respond. We will continue working with WaterNSW to ensure that the proposed triggers are integrated into flow forecasting procedures.

We also need to undertake further work to understand cultural needs in the context of an extended drought and first flush. Community consultation will be undertaken in 2022 through the Western Regional Water Strategy and the Barwon–Darling Water Sharing Plan remake.

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