Water Flows in the Murray-Darling Basin: Observed versus expected

Summary Report

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WENTWORTH GROUP OF CONCERNED SCIENTISTS

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Abstract

The Wentworth Group of Concerned Scientists has conducted a study to fill a gap in publicly available research that evaluates whether environmental water recovery has led to observable increases in river flows at two key sites along the Murray-Darling Basin; Chowilla and Wilcannia. These sites were chosen as they are representative of the health of the southern and northern basins respectively. This study was undertaken to assess whether recovered water is contributing to increased flows as would be expected.

This assessment found that despite 2,016 GL of water being recovered for the environment (63% of that envisaged under the Basin Plan) at a cost of $8.5 billion, and during the relatively wet period from 2010-2018:

1. Environmental flow targets set by the Murray-Darling Basin Authority, which are required to be met to produce environmental improvements, have failed to be achieved.
2. In general, excluding natural flood events, annual average flows can be up to 40% to 60% smaller than expected under the Basin Plan.
3. In general, observed flows are similar to, or less than, the baseline (pre-Basin Plan) model results, revealing that instead of an increase there has actually been no improvement or even a decline in water flows since the implementation of the Basin Plan.

This summary document complements the technical report which includes the full methodology and analysis and is available at www.wentworthgroup.org.

Introduction

The Murray-Darling Basin Plan is based on an agreement between the Commonwealth and Basin governments to rebalance water use and restore the health of the Murray-Darling Basin. The Basin Plan is underpinned by the Commonwealth Water Act (2007) which requires the Murray-Darling Basin Authority (MDBA) to determine an Environmentally Sustainable Level of Take; the maximum amount of water that can be taken without harming the health of the rivers.

A fundamental element of the Basin Plan is to reduce over-extraction and ensure more water remains in our rivers for environmental outcomes. One third of water in the basin is extracted for human use, and well over 90% of this is used for irrigation. This has meant that returning more water to the rivers has necessitated reducing how much water is used for irrigation.

The Water Act permits the Commonwealth Government to acquire water through purchasing water entitlements, or improving water use efficiency. The Basin Plan established that 3,200 gigalitres (GL) of water needs to be returned, per year, to achieve an Environmentally Sustainable Level of Take. This number was partially based on a set of 124 site-based environmental **flow targets** which, if achieved, would mean the flow was assumed to be sufficient to maintain riverine health. However, the gigalitre value is heavily disputed by independent scientists, including the Wentworth Group of Concerned Scientists, who generally evaluate that the number should be well above 4,000 GL.

As of December 2018, the amount of water recovered for the environment totaled 2,016 GL. As of that same date, there has been no public evaluation of the effectiveness of the water recovered to deliver the intended environmental outcomes as described by the MDBA's environmental health flow

indicators or modelling. The Wentworth Group of Concerned Scientists has undertaken this study to assess whether recovered water is contributing to increased flows in the Murray-Darling Basin.

Method

To undertake this assessment, two river gauge sites were chosen which broadly represent flows in the northern and southern basins (Figure 1). These sites are:

a) Chowilla on the Murray River, indicative of the volume of flows to South Australia as well as the health of the Murray River and associated wetlands and floodplains; and
b) Wilcannia on the Darling River, indicative of the health of the Barwon-Darling system upstream of the Menindee Lakes.

Figure 1: Map of Basin showing location of the Wilcannia on the Darling River above Menindee Lakes, and Chowilla on the Murray River near the South Australian border (source: MDBA).

This investigation looked at the relationship between water recovery and observed changes to river flows since 2010. Two approaches were used to evaluate the:

1. Characteristics of observed flows compared to the MDBA environmental flow targets; and
2. Observed flows compared to MDBA modelled flows under similar climate conditions.

The second approach would have been straightforward if the MDBA had continued to make publicly available annual updated model runs in each valley, that represent modelled river flows without the Basin Plan. These modelled flows could be compared to actual measured flows in the river to determine improvements that are attributable to the Basin Plan. However, these models have not been updated to run beyond 2009. This assessment therefore required using past modelled flows which occurred as a result of similar upstream water availability as a proxy for current expected flows. Detailed methodology for this assessment is available in the technical report.

Observed flow data used in this assessment covered the period 2010 to 2018. This period signifies the timeframe over which water recovered had reached approximately 1,000 GL (in 2010) and increased to 2,016 GL (in 2018). So far $8.5 billion has been spent under the Basin Plan, much of which has been directed to water recovery.

The three primary data sets used in this analysis were:

- **Observed**: Observed flow measured at each site's stream gauge (2010-2018);
- **Baseline**: MDBA modelled results showing expected flow with pre-Basin Plan water recovery (1895-2009);
- **Expected:** MDBA modelled results showing expected flow with Basin Plan water recovery (1985-2009).

The expected results are modelled by the MDBA using 2,145 GL of recovered water (see Box 1). As mentioned, to date, 63% or 2,016 GL of environmental water has been recovered. To match the amount of water in the Basin Plan model, only an additional 129 GL of water needs to be recovered for the environment.

The observed results are compared to MDBA modelled outcomes and are likely to be far less than expected if compared to the original Basin Plan water recovery target of 3,200 GL. Despite this the observed results should show some improvement and be above the baseline (representing no Basin Plan water recovery).

While this analysis is limited in that not all the environmental water has been recovered, a strength is that the last decade has been relatively wet in comparison to the preceding 10-year long millennium drought. As there has been a relative abundance of water in the Basin, the analysis has been undertaken under more favorable water availability conditions compared to droughts. If the last nine years were under drought conditions the results from this analysis would likely be much worse. Additionally, the gap between expected and observed outcomes would be far greater if the comparison was against a model simulation of 3,200 GL of water recovery as originally envisaged by the Basin Plan.

Box 1: How much water recovery was modelled under the Basin Plan?

The agreed water recovery under the Basin Plan was 2,750 GL + 450 GL = 3,200 GL. The 450 GL here is additional water obtained through efficiency measures that require a neutral or positive socio-economics test; none of which has been recovered. From the 3,200 GL total, supply measures were adopted which allow for a reduction of 605 GL by the year 2024.

The Basin Plan modelled water recovery was therefore 3,200 GL – 450 GL – 605 GL = 2,145 GL.

The Basin Plan model also included full implementation of pre-requisite policy measures (policy which has yet to be enacted but was assumed in the model) as well as flow constraint levels from the year 2012.

Results: observed versus target flows

The MDBA developed a methodology to derive the Environmentally Sustainable Level of Take which uses site-based environmental flow targets across the basin (see Box 2). The sites are referred to as hydrological indicator sites and water flow through these sites is measured by flow gauges. The targets are environmental flow indicators and were selected on the assumption that achieving these flow indicators is a necessary precondition to achieve ecological restoration. The targets include a combination of flow characteristics including magnitude, duration, timing and frequency. Full indicator site flow target details are available in the MDBA Environmentally Sustainable Level of Take and Northern Basin Review reports. They are quantified in terms of flow characteristics including magnitude, duration, timing and frequency. Full indicator site flow target details are available in the MDBA Environmentally Sustainable Level of Take and Northern Basin Review reports.

This assessment evaluates the site-based flow targets using observed flows since 2010, and compares against the MDBA Baseline model simulation without water recovery and the expected MDBA model simulation with Basin Plan water recovery. These results are summarised in Table 1.

Table 1: Site-based flow target achievement at Chowilla on the Murray River and Wilcannia on the Darling River.

Site-based environmental flow target			Flow (ML/d)	Observed	Baseline	Expected
Chowilla	1	Base flows lasting two months in winter	20,000	Fail	Fail	Pass
	2	Small flows lasting a month in winter	40,000	Fail	Fail	Pass
	3	Small flows lasting three months in winter	40,000	Fail	Fail	Pass
	4	Medium flows lasting two months in winter	60,000	Fail	Fail	Pass
	5	Large flows lasting a month any time of year	80,000	Fail	Fail	Fail
	6	Large scale natural floods	100,000	Natural floods not targeted by Basin Plan water recovery		
	7	Large scale natural floods	125,000			
Wilcannia	1	Base flows any time of year	2,350 GL	Fail	Pass	Pass
	2	Small flows lasting a week any time of year	6,000	Pass	Pass	Pass
	3	Large flows lasting a week any time of year	20,000	Fail	Pass	Pass

In addition to the listed targets at Chowilla, two flood level descriptors are listed by the MDBA but not targeted for active achievement in the Basin Plan. These descriptors represent flows above 100,000 ML/d and 125,000 ML/d. While they are not actively targeted in the Basin Plan these large flow levels are most important for achieving environmental outcomes linked to watering floodplains and wetlands. In the time period assessed these descriptors failed to be achieved.

From Table 2, for Chowilla, we can see that:

- Under observed water recovery, none of the indicators meet the targets and the flows are failing to achieve requirements for ecological restoration;
- These observed results are no better than the MDBA modelled baseline, so no improvements have been measured in the achievement of the MDBA flow targets over the period of this assessment even with all of the current water recovery;
- However, under the MDBA modelled expected water recovery, all indicators are met, except for very large floods that are beyond influence of water recovery.

For Wilcannia, we see that two out of three observed targets fail to be achieved. Further:

- Under observed water recovery only small flows have passed the target, with base flows and large flows failing to achieve hydrological conditions assumed necessary for ecological restoration.

These site-based environmental flow target evaluations reveal that, for the period 2010-2018, the MDBA targets, assumed to be required to produce environmental outcomes for this section of the river, have failed to be achieved.

Box 2: Why use these environmental flow targets?

The environmental flow targets examined in this report were set by the MDBA in 2012 as part of the Environmentally Sustainable Level of Take methodology which formed the basis for the SDL. They also informed the Basin Watering Strategy which describes the environmental watering requirements that guide the Commonwealth Environmental Water Holder.

These targets were used to develop water recovery amounts and should therefore be used to evaluate the Plan's effectiveness in delivering these amounts. To date, neither the MDBA nor the Commonwealth Environmental Water Holder have used these targets in their effectiveness reporting.

Based on the lack of achievement of these flow targets it is possible to draw inferences about the lack of inundation to wetlands and flood-dependent vegetation area. The MDBA has modelled the relationship and Figure 2 shows this for South Australian floodplain near the Chowilla site.

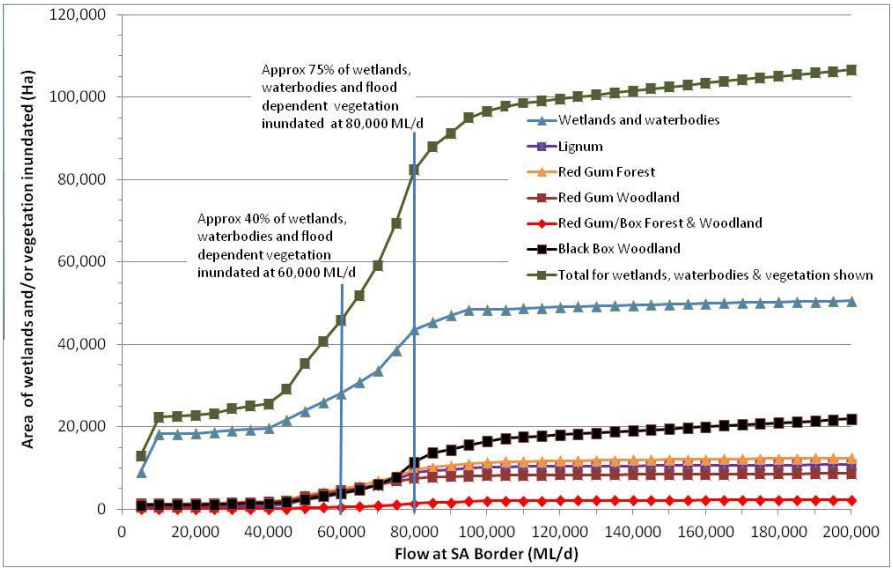

Figure 2: Relationship between inundation of wetlands and flood-dependent vegetation and flow in the Murray River on the South Australian floodplain near Chowilla (Source: MDBA).

Figure 2 shows that:

- Flows of 60,000 ML/d to 80,000 ML/d (blue lines) were expected under the Basin Plan to water at least 45,000 ha (40%) of wetlands and flood-dependent vegetation in the South Australian floodplain. This could be increased to 82,000 ha (75%) with a Constraints Management Strategy.

- As these flow rates were not achieved, only a small portion of the floodplain will be maintained. The only area being watered is 9,000 ha (10%) of floodplain which are under the influence of existing infrastructure built under the Living Murray program. Implementing the Constraints Management Strategy could see up to nine times the area of wetlands and flood-dependent vegetation watered.

These lack of flow achievements are likely to have had an adverse impact on river, wetland and floodplain ecology which depend on at least one moderate flood every decade. Given water availability has been relatively high since 2010, the inability to achieve environmental flow indicators or improve on pre-Basin Plan hydrological outcomes over the past 8-10 years is concerning.

Results: observed versus expected flows

The second approach undertook a comparison of modelled and observed streamflow. This assessment required using past modelled flows, which occurred as a result of similar upstream water availability, as a proxy for current expected flows. This analysis showed the annual difference in observed flow over the period 2010 to 2018 compared to the expected Basin Plan flow (Figure 3).

In this approach, it is logical to expect that we would be achieving flows better than the baseline, and close to what was expected by the MDBA considering how much water has been recovered.

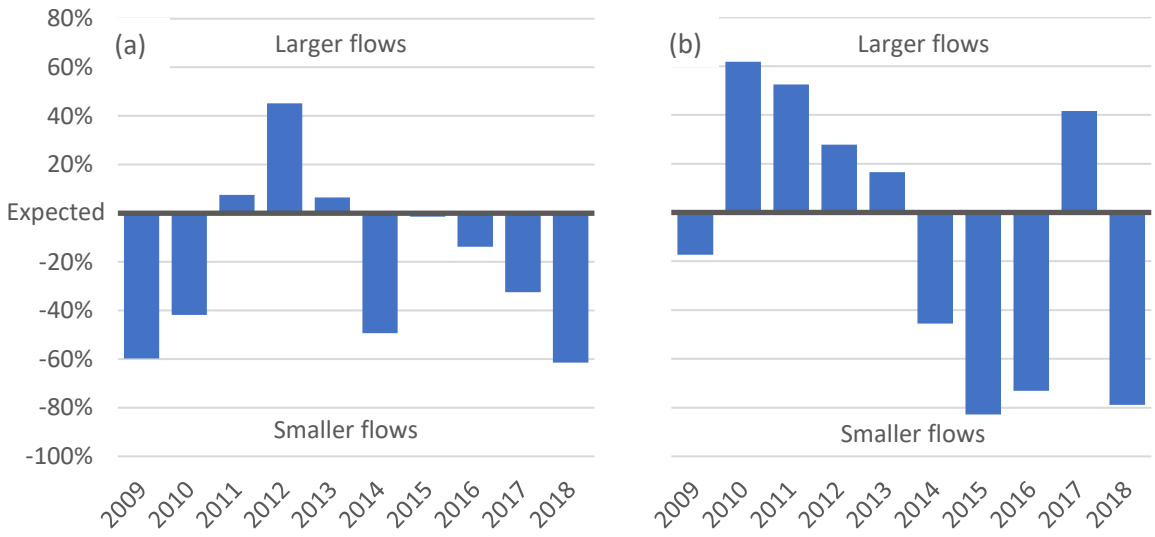

Figure 3: Annual difference in observed flows and expected flows at (a) Chowilla and (b) Wilcannia.

From Figure 3, for Chowilla we see that:

- In the wet years of 2010-2013 and 2017 only a single annual observed flow volume was substantially larger than expected. However, in the majority of all other years, annual observed flows are up to 60% smaller than expected after environmental water recovery.

For Wilcannia we see that:

- Observed flows were well above the Basin Plan expectation over the period 2010-2013 and 2017. These were exceptionally wet years, with large floods. However, as conditions became

drier, observed flows have been consistently smaller than expected under the Basin Plan with up to 80% smaller flows than expected.

- Only in the wet years were flows higher than expected. In all other years, they were lower than expected, in most cases substantially lower.

From the volume of environmental water recovered to date, the observed flows should be close to the expected values and larger than the baseline. However, from Figure 4, we see that in both wet and dry years this is generally not the case. In most instances the observed flow is less than expected (and even less than the baseline in several cases). Wilcannia in wet years provides the only exception where the observed flow is greater than expected and this is as a result of natural flood events.

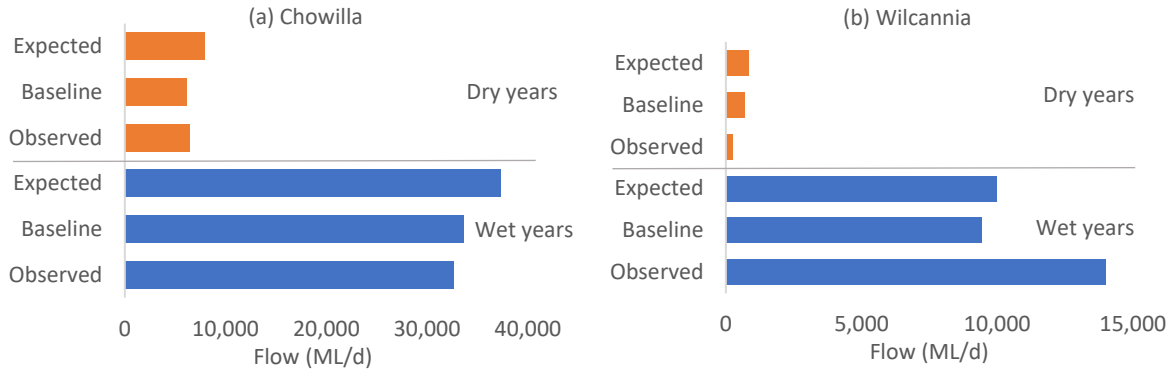

Figure 4: Average daily expected flows (ML/d) over 2010-2018 at (a) Chowilla and (b) Wilcannia compared with baseline and observed, separated into dry and wet years.

These results show that Basin Plan implementation has not improved the flow regimes in the rivers as were expected in the modelling. Additionally in most cases the observed flows are similar to or below the baseline model results, meaning that instead of recording an improvement in the river flows, there has actually been a decline.

It is noted here that in wet years, there is generally a large volume of water for all users. The Basin Plan needs to ensure environmental water is increased, when compared to historical practices, in dry years, when water resources are scarce. Current levels of environmental water should be impacting on the observed 'dry-year' flows and making these closer to the expected results. The results here show that it is unlikely that there have been overall environmental improvements since the beginning of the Basin Plan.

Discussion

There are several factors that might contribute to the apparent failure of water recovery to provide benefits to river flows as expected. Of particular note is the accuracy of the Baseline and Basin Plan models in simulating the Basin and the ability to compare these model outputs with observations. It is also noted that the nine years of flow data used in this assessment are not fully representative of the entire variability in the observed record of Basin flows. Additionally, the 2012 flow targets used to underpin the SDL are not being actively pursued by river managers. Further analysis by the MDBA is required to fully understand the reasons for the poor results presented here, but two reasons are discussed below.

In the Murray River, medium to large floods have reduced in frequency because of increased river regulation through infrastructure (dams and weirs), and changes in the rules (or policies) that govern

how much water can be released from dams and under what conditions. These regulatory decisions serve to constrain river flows from what occurs naturally. The Basin Plan requires that the Basin States make every effort to relax these constraints, guided by the MDBA's Constraints Management Strategy. Many of these constraints have not been adequately relaxed by the New South Wales and Victorian governments, and indeed, in some instances (e.g. Goulburn River and Murray River downstream of Yarrawonga), they have been further tightened. The tightening of constraints, and inadequate implementation of the Constraints Management Strategy, explains why River Murray flows at Chowilla are not achieving the objectives of the Water Act.

In addition the Basin Plan requires State governments in the Southern Basin to implement policies which enable environmental water to be called from storage to supplement water already in the river and to recognise this as environmental water as it moves through the system. The ability to call environmental water from storages such as Hume Dam on top of flows already in the river is governed by operational flow constraints which are yet to be relaxed as agreed by governments in 2012.

In the Darling River, the inability to reach two out of the three environmental flow indicators at Wilcannia may be due to insufficient water recovery in the Northern Basin and an overestimation by the MDBA of the ability to deliver these flow outcomes without stronger protection (shepherding) of low flows. Under current NSW water sharing rules in the Barwon-Darling additional environmental water in the river results in irrigators having greater opportunities to pump environmental water legally. This is because pumping rights are linked to river flow rates and there has been no adjustment to these pumping flow rates after environmental water has been purchased.

This means that water that should have been left in rivers, for environmental purposes, can be extracted from the river for consumptive use. Protecting these environmental flows across borders is an essential step in improving the health of the river ecosystems, as well as providing tax payer value for money for environmental water purchases.

Conclusions

The Wentworth Group of Concerned Scientists conducted a study to fill a gap in publicly available research to evaluate whether environmental water recovery has led to observable increases in river flows. This assessment was conducted at Chowilla and Wilcannia sites, which are representative of the health of the southern and northern basins respectively, and the results presented here are likely to be replicated at other locations.

This assessment found that despite 2,016 GL of water being recovered for the environment (63% of that envisaged under the Basin Plan) at a cost of $8.5 billion, and during the relatively wet period from 2010-2018:

1. Environmental flow targets set by the MDBA which are required to be met to produce environmental improvements have failed to be achieved.
2. In general, excluding natural flood events, annual average flows can be up to 40% and 60% smaller than expected under the Basin Plan.
3. In general, observed flows are similar to or less than the baseline (pre-Basin Plan) model results, revealing that instead of an increase, there has actually been no improvement or even a decline in water flows since the implementation of the Basin Plan.

Recommendations

As a result of this study, the Wentworth Group of Concerned Scientists has identified the following recommendations:

1. The Murray-Darling Basin Authority should evaluate the success of water recovery in the Basin Plan using an approach which is based on the measurement of river flows against expected flows, taking into consideration variable climate.
    a. The preferred method is to update the Baseline (pre-Basin Plan) models in each valley every year with observed rainfall, evaporation and storage levels. These results provide a simulation of flows without Basin Plan water recovery and can be directly compared to current observed gauged flows to achieve the objective above.
    b. If the Murray-Darling Basin Authority is unable to undertake the assessment through updating the Baseline models then an alternative method, such as the one presented here, should be adopted.
    c. This evaluation should be conducted at all Murray-Darling Basin Authority hydrological indicator sites, and the model outputs and results should be made publicly available for independent testing and verification.
    d. This assessment should be adopted as a mandatory element of the Murray-Darling Basin Authority's annual Basin Plan effectiveness reporting. This should include full investigations if flow parameters are not achieving expected outcomes. Action should be taken where flows fail to achieve targets.
2. That a single set of flow indicators, reflecting of an Environmentally Sustainable Level of Take, are agreed to by all jurisdictions and used for environmental water planning, management and evaluation.
3. To improve the achievement of all flow indicators at Chowilla we recommend that pre-requisite policy measures (assumptions made when modelling the Basin Plan) be properly implemented to maximise the benefits of environmental water at rates supported by a fully implemented Constraints Management Strategy that enable 80,000 ML/d at Chowilla and into South Australia to be achieved.
4. To improve the condition of high flow indicators at Chowilla and elsewhere in the Goulburn and Murrumbidgee we recommend that the Constraints Management Strategy be implemented in full by the New South Wales and Victorian Governments, which will allow for larger flow volumes during high flow events. The Commonwealth should pursue compulsory implementation if required, as recommended by the South Australian Royal Commission into the Murray-Darling Basin. Without the Constraints Management Strategy significant areas of floodplain in the Basin is likely to perish.
5. To improve low flows at Wilcannia, we recommend greater protections against pumping during periods of low flows, accompanied by protection of event based environmental flows for environmental use downstream and across state borders.