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REVIEW OF WATER REFORM IN THE MURRAY-DARLING BASIN

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Wentworth Group of Concerned Scientists

In Association with

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Summary

It has been thirteen years since the historic National Water Initiative was signed, and five years since the Australian Parliament agreed to the Murray-Darling Basin Plan. Since then, nearly $8 billion of taxpayers' money has been spent largely to address the chronic over-allocation of water in the river systems of the Murray-Darling Basin.

This report is the first independent and comprehensive review of the Basin Plan. Its purpose is to evaluate progress towards the social, environmental and economic objectives of the reforms, with the view to setting out steps necessary to deliver the Basin Plan in full by 2026. This report also looks further into the future and sets out a suite of long-term reforms that are necessary if the nation is to achieve its ultimate goal of restoring the health of river systems in the Murray-Darling Basin.

Overall, the review finds there has been significant progress since 2004, but this progress has slowed to a trickle since the Basin Plan was adopted in 2012. Without major changes in implementation, it is almost certain that the Basin Plan will fail.

A healthy working Murray-Darling Basin is vital for the wellbeing and livelihoods of more than three million people who live in the Basin or rely on its water resources. It is also of great importance to Australia. A healthy working Basin means communities with reliable fresh water for growing food and fibre, an open Murray mouth with sufficient water to export salt, and healthy populations of water-dependent species and ecosystems, including 16 wetlands of international conservation significance.

Since Federation, successive governments have grappled with the challenge of managing water resources in the Murray-Darling Basin. More than a century of growth in water use has resulted in significant environmental degradation, where 21 of the 23 catchments in the Basin are now in poor or very poor health.

In 2004, a major intergovernmental agreement - the *National Water Initiative* - was signed by all governments of Australia. It represented a once-in-a-generation opportunity to restore the health of river systems in a way that promotes economic prosperity while using less water.

In 2007, the *National Plan for Water Security* provided a legislative framework (the *Commonwealth Water Act 2007*) and what amounted to a $13 billion public investment to deliver these reforms. The 2007 Water Act required the newly created Murray-Darling Basin Authority to produce a Basin Plan to *"*ensure the return to environmentally sustainable levels of extraction for water resources that are over-allocated or overused*"*.[1]

The Basin Plan was established by the Australian Parliament in 2012 to recover 3,200 GL of water for the environment from an annual consumptive use of 13,623 GL, or implement projects which deliver 'equivalent' outcomes. This volume fell substantially short of the Murray-Darling Basin Authority's best estimate that between 3,856 GL (high uncertainty) and 6,983 GL (low uncertainty) was required for a healthy river. The Basin Plan also allowed for significant increases in groundwater extractions, and did not take into account the likely future impact of climate change, particularly in the southern Basin where the latest projections show reduced river flows are likely to have significant impacts on water availability.

In this review, we find that national water reform has improved water trade which has provided greater flexibility for irrigators to manage risks and adapt with less water. Water is now moving to higher value uses, assisted by permanent and temporary water trade. The Basin's economy as a whole has grown since 2002 and has been maintained in the five years since the Basin Plan has been in place.

Since the 2004 National Water Initiative, there has also been substantial progress towards the recovery target, with two thirds of the water recovered (2,107 GL) and with almost two thirds of the funding spent ($7.9 billion). While no overall improvement in the condition of river systems has been observed yet, there have been local improvements in salinity, water quality, and the condition of freshwater species in river reaches receiving additional water.[2] The Ramsar-listed Coorong is still in poor condition due to inadequate freshwater flow, however the condition of the Lower Lakes, also an internationally recognised environmental asset, has improved through the combination of the return of wetter conditions since the millennium drought and the delivery of environmental flows.[3]

Notwithstanding these important achievements, strong political pressure has resulted in national water reform slowing to a trickle. This pressure has been exerted on governments to halt water purchase and unwind water recovery targets. Only one quarter of the water recovered so far (530 GL) has been acquired since the Basin Plan was adopted, while the cost of water recovery has doubled.

One of the reasons for this pressure is that in some districts, water recovery has compounded the many other economic pressures facing rural and regional Australia, and governments have failed to support communities in these districts. Whilst individual irrigators have benefited from the reforms, less than one percent of the $13 billion was made available to assist communities affected by the reforms to adapt to a future with less water.

This review finds that even with the Basin Plan implemented in full, it will be impossible to achieve the objective that the "mouth of the River Murray is open without the need for dredging in at least 95% of years"[4] without significantly more river flow, permanent dredging or other major interventions.

This review also finds that some Basin states are retarding progress and proposing changes which are inconsistent with the objectives of the Basin Plan: some have put forward projects as substitutes for environmental water, most of which do not satisfy the requirements of the Basin Plan;[5] some are failing to remove constraints which prevent environmental water from flowing downstream; and some are attempting to adjust river management rules and change computer model settings in a way that will allow larger volumes of water to be legally pumped for private use (including water that has been recovered for the environment).

A series of institutional changes since 2012 have eroded regulatory oversight of the national water reforms: in 2013, the Murray-Darling Basin Ministerial Council abolished the Sustainable Rivers Audit, a program that was established to measure the condition of the river systems in the Basin; in 2014, the Commonwealth Government abolished the National Water Commission; and in 2017, revelations of possible water theft and meter tampering exposed inadequate monitoring and compliance regimes.

The consequence of this systematic weakening of the 2004 reforms and undermining of the Murray-Darling Basin Plan has now placed water reform at great risk, leaving Australia's most productive basin seriously compromised. It will be the people living downstream and future generations that carry the cost of the degraded river system.

What is needed is to return to a genuine spirit of cooperation that existed when the nation's governments signed the National Water Initiative in 2004. Cooperation among states and the Commonwealth is essential to restoring public trust in the integrity of the Basin Plan and ensuring water reform is both fair and effective.

In December 2016, in response to growing concerns of the commitment of governments to reform, all Murray-Darling Basin First Ministers agreed to ensure the Basin Plan is delivered "on time and in full".[6] We welcome this statement. On the basis of this review, we put forward five actions that we believe are necessary to deliver the Murray-Darling Basin Plan if governments are to deliver on this promise:

1. Rebuild trust with greater transparency;
2. Guarantee recovery of the full 3,200 GL or genuinely equivalent outcomes;
3. Ensure that water recovered achieves measurable improvements to the river system;
4. A regional development package that puts communities at the centre of reform; and
5. Prepare for the prospect of a future with less water.

The Basin Plan agreement to recover 3,200 GL is an important step in the journey of water reform. With these actions and with the $5 billion remaining, it is possible to restore public trust, complete these reforms and in doing so, put Australia on a path towards restoring the health of the Murray-Darling Basin. When these reforms are in place, environmental assets will be in better condition, the Basin's economy will be more prosperous in the long-term, and communities will have greater confidence in their future.

Key findings

Progress towards recovering 3,200 GL or equivalent outcomes

1. Two thirds (2,107 GL) of the surface water target has been recovered as of September 2017, and nearly two thirds ($7.9 billion) of the $13 billion has been spent. Three quarters (1,577 GL) of this water was acquired prior to the Basin Plan, between 2009 and 2012.
2. Since 2014, water recovery has stalled and is no longer on a trajectory to meet the Basin Plan target (Figure 8). Water has been recovered through a combination of water purchase (57%), infrastructure efficiency upgrades (34%) and other mechanisms (8%). Recovered volumes may be less than claimed because of the reduction in runoff into rivers and leakage into groundwater as a result of upgrading and consolidating of irrigation systems.
3. The Murray-Darling Basin Authority has put forward a draft determination to increase the sustainable diversion limits by 605 GL on the basis of 37 projects put forward by state governments. Our asssessment of these projects found that only one project should be approved, eleven projects (representing in the order of 150 to 270 GL water savings) require additional information before a proper assessment can be undertaken, and twenty five projects (in the order of 316 to 436 GL) do not satisfy Basin Plan requirements and should be rejected.
4. Governments have listed water use efficiency projects to contribute to recovering 450 GL of water to enhance the health of the Basin's environment without harming communities and the economy overall, but there has been no reported recovery of this water to date.
5. Winter rainfall and streamflow in the southern Basin have declined since the mid-1990s and the Basin has warmed by around a degree since 1910. The Basin is likely to experience significant changes in water availability due to human-caused climate change, particularly in the southern Basin where annual rainfall is projected to change by -11 to +5% by 2030. Any reduction in precipitation is likely to have significant impacts on water flows in rivers, in some cases driving a threefold reduction in runoff, with implications for water recovery under the Basin Plan.

Environmental outcomes

1. Water recovered for the environment has assisted export of nearly 1 million tonnes of salt each year, more than would have been exported without the Basin Plan, but less than the Basin Plan target of 2 million tonnes.
2. Rivers and wetlands that received environmental water are in better condition, with measured improvements in water quality, salinity and fish. However, there are many more sites across the Basin which have not received sufficient environmental flow and there is no evidence yet to demonstrate improvement across the Basin as a whole. Environmental water recovered so far has not been sufficient to arrest the long-term deterioration in key river condition indicators (e.g. waterbirds and ecological processes). While localised improvements have been made in some Ramsar wetlands of the Basin, e.g. in the Gwydir wetlands, most remain in a state that is more degraded than the ecological character for which they were listed under the treaty. River operating constraints, inadequate environmental flow protection and non-compliance are still impeding the delivery of water downstream and onto floodplains.
3. Environmental water and natural flows have contributed to the improved environmental condition of the Lower Lakes, a Ramsar wetland of international significance, following the millennium drought. The Coorong is still in poor condition due to inadequate freshwater flow.
4. Even when the 3,200 GL or equivalent outcomes is delivered in full, it will not be possible to achieve the Basin Plan target of maintaining an open Murray mouth in 95% of years without continued dredging of the mouth, except during flood events.

Socio-economic outcomes

1. Irrigation businesses across the Murray-Darling Basin have benefited from the conversion of annual entitlements to permanent property rights and the capacity to trade those rights, a capital injection of $2.7 billion of public investment to purchase water entitlements, and $3.6 billion in irrigation infrastructure subsidies.
2. The gross value of irrigated agricultural production has risen since the early 2000s and has been maintained in the past 5 years. Money paid to irrigators by the Commonwealth to recover water and the ability to trade water has helped some irrigators adjust to the drought and cope with other pressures.
3. While agricultural production has been maintained, employment in agriculture in the Basin has declined by nearly 26% in the past 15 years. This decline has slowed considerably in the past 5 years, but has not increased in line with the rise in agricultural employment nation-wide. Most of the decline in agricultural employment in the Basin occurred in dairy farming and growing cotton, grapes, fruit and livestock grain. Despite this, there was a 2% increase in the overall number of people employed in the Basin from 2011 to 2016, largely due to increases in employment in other sectors such as education and training, health care and social assistance.
4. Employment and economic production in some regional centres, such as Griffith and Shepparton, have grown significantly over the past decade while other, usually smaller, communities have experienced declines. More efficient water use and water trade have contributed to these structural changes, including expansion of high-value production in the southern Basin.
5. The total number of agricultural businesses has also declined across the Murray-Darling Basin in line with national trends. Factors behind the decline include drought, technological improvements which have reduced demand for labour, and increasing farm business size to improve profitability. In some districts such as Deniliquin and Moree, water reforms have also been modest contributing factors. In these districts, water purchase have reduced water available for production while improvements in water efficiency and trade have led to rationalisation of agriculture (e.g. automation, out-sourcing and consolidation) and reduced demand for labour.
6. A major failure of water reform has been insufficient investment in structural adjustment to support communities affected by water reforms to adapt to a future with less water. Less than one per cent of the $13 billion has been made available to assist these communities.

Recommendations: Five actions necessary to deliver the Basin Plan "on time and in full"

COAG should agree to the following five actions to deliver the Murray-Darling Basin Plan 'on time and in full'. Future payments by the Commonwealth should be contingent on states delivering these actions, with annual audits of progress by COAG.

1. Rebuild trust with greater transparency, by:

- **Improving metering and compliance** by Commonwealth, state and territory governments agreeing to comprehensive measurement of consumptive water use and water interception, including groundwater, across the whole Basin to a standard suitable for compliance action.
- **Improving accountability** with professional water accounting standards and independent auditing against standards, accompanied by annual audits of expenditure of public funds and annual reviews of the Basin Plan's progress by an independent auditor.
- **Reinstating a basin-wide river monitoring program** to measure and report regularly on the overall condition of the 23 river systems across the Basin as well as targeted programs reporting on progress towards specific Basin Plan objectives against what would have occurred without the Basin Plan.
- **Strengthening the capacity of the Murray-Darling Basin Authority to fulfil duties as a regulator**.

2. Guarantee recovery of the full 3,200 GL or genuinely equivalent outcomes, by:

- **Securing the remaining 1,093 GL or equivalent**, including the 450 GL to enhance the Basin's health, through a combination of strategic water purchase, water efficiency programs and on-farm investment, but only where such recovery results in measurable additional water to the river system. Water recovered must account for the reduction in runoff and groundwater recharge that would have otherwise benefitted the environment.
- **Ensuring environmental outcomes are equivalent or better** as a result of any adjustment to the sustainable diversion limit by agreeing to the conditions in Table 10 on page 52. Rivers need water, and 'complementary measures' such as carp herpes virus, are not a substitute for real water.
- **Making sure water recovered for the environment is protected in the river and not being undermined** by changes to state water resource plans, river management and operating rules, changes to baselines or model assumptions (as defined in Table 12 on page 59), and other land use changes that affect water availability in the catchments (e.g. farm dams, plantations, floodplain harvesting).[7]

3. Ensure that water recovered achieves measurable improvements to the river system, by:

- **Removing constraints (physical and policy)** that restrict the use or passage of environmental water to target floodplains and wetlands, by re-configuring infrastructure and enforcing planning restrictions in designated floodways (see Table 13 on page 62), and where appropriate, compensating for any third party impacts.
- **Ensuring sufficient water reaches the Lower Lakes, Coorong and Murray Mouth** to export salt from the Basin, reduce water quality risks, and deliver freshwater to maintain the ecological character of the Ramsar wetlands.
- **Aligning the Basin Plan targets, the Basin-wide environmental watering strategy, and water resource plans,** at the catchment level as part of the accreditation process to achieve outcomes.

4. A regional development package that puts communities at the centre of reform, by:

- **Assisting communities most affected by water recovery to restructure their economies to adapt to a future with less water.** Assigning for example, 10% of the remaining $5.1 billion would release up to $500 million for regional development initiatives.
- **Linking public funding directly to the Basin Plan**, by the Commonwealth working directly with community leaders, local government, regional development boards and natural resource management agencies to recover the water in a manner that optimises regional development opportunities for those communities.

5. Prepare for the prospect of a future with less water, by:

- **Improving scientific understanding of the potential future stresses** caused by extreme weather events (e.g. more frequent and more severe drought and higher evaporation from rising temperature) and long-term changes in climate including water availability, supported by a climate change adaptation program for environmental assets, industries and public infrastructure.
- **Expanding the mandate of the Basin Plan** to integrate water planning with broader natural resource management to improve the overall environmental condition of the Basin.
- **Investing in knowledge and capacity** to enhance agricultural productivity, sustainable production and food and water security, and protect the natural resource base in a variable and changing climate.
- **Ensuring water reform** remains a permanent item on the COAG agenda, and recognising the long-term nature of national water reform via the establishment of an independent expert body to undertake regular reviews of progress.

Water reform is crucial to the future of the Basin

Benefits of a healthy and productive Murray-Darling Basin

The Murray-Darling Basin is Australia's largest river system, spanning one seventh of the continent and traversing four states and a territory (Figure 1). It is home to 2.2 million people and it supplies freshwater to a further 1.3 million, including the cities of Adelaide, Whyalla and Port Augusta. The Basin has become the nation's food bowl, generating a third of the national food supply and nearly half of all irrigated agricultural production in Australia.[8, 9] The Basin also contains a number of nationally significant environmental assets, including 16 internationally recognised Ramsar wetlands including the Coorong, Lower Lakes and Murray mouth (Figure 1).

A healthy Murray-Darling Basin is vital for the wellbeing and livelihoods of these people, and of great importance to the whole of Australia. A healthy Murray-Darling Basin means:

- Clean water for drinking and for growing food and fibre, with flows that flush salt, sediment and excess nutrients out of the Basin;
- Economic benefits from recreation, fishing, tourism and education;
- Reduced risk of algal blooms, hypoxic blackwater events, acidification, salinisation and erosion which pose significant health risks and impacts farming, fishing and tourism;
- Improved soil fertility and enhanced pastures in grazing landscapes as a result of the natural wetting cycles of floodplains;
- Improved water security for farmers during dry periods, improved capacity of wetlands to buffer floods and refuge for animals during droughts;
- Cultural and economic benefits for indigenous nations;
- Resilience to climate extremes with greater capacity to adapt to a changing climate in the future; and
- Habitat, food, migration pathways and breeding opportunities for native fish, waterbirds and other native wildlife that rely on water in the Basin, some of which are nationally threated and/or recognised by international agreements.

Healthy river systems are a pre-requisite for delivering all these benefits. Water is key to protecting and restoring the health of the Basin's ecosystems that provide these benefits.

Surface water in the Murray-Darling Basin is highly variable and there is strong competition over its use. Through past mistakes, many rivers are over-allocated or overused.[7] Without sufficient quality and quantity of flow, the Basin cannot support important environmental assets that depend on water, nor can it sustain the basic functions such as safe drinking water, reducing salinity for viable irrigation industries, as well as discharging salts and sediments to the sea through an open Murray mouth.

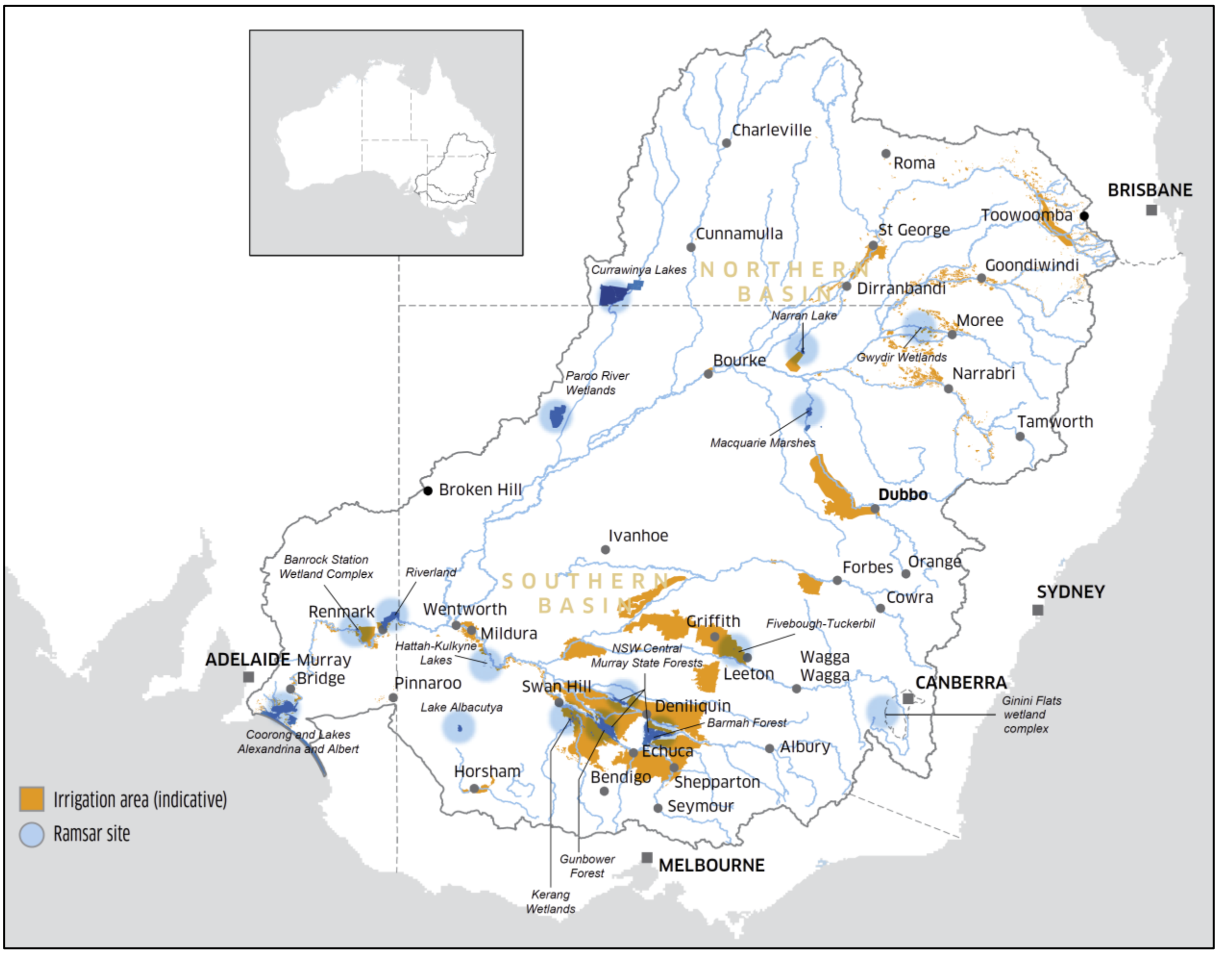

Figure 1. Map of the Murray-Darling Basin showing rivers, towns, major irrigation areas and Ramsar wetlands of international importance (Source: MDBA, 2016)[10]

History of a century of water reform in Australia

Australia is the driest inhabited continent and flows in the Murray-Darling Basin are among the most variable in the world. Water has always been vital to national development and human well-being. For over a century, successive governments have grappled with the challenge of managing water resources in Australia. There are many examples in history where governments have taken decisive action in response to these challenges. The first landmark water reform in Australia was catalysed by the severe drought that gripped the nation at the time of federation (1895 – 1902; Figure 2). After more than a decade of conflict between states, the Murray Waters Agreement in 1915 set out, for the first time, rules for sharing water of the River Murray between state and Commonwealth governments.

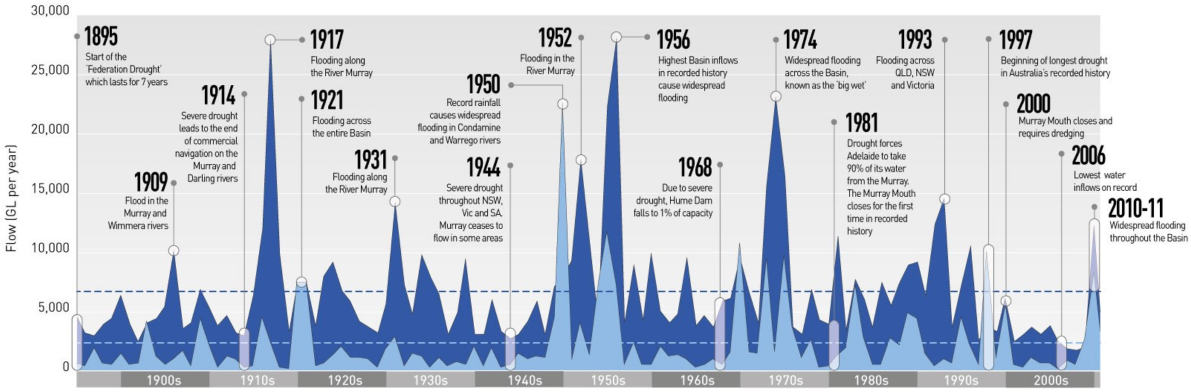

Figure 2. Historical river flows in the Murray-Darling Basin from 1895 to 2011 with major events highlighted. Annual flows are shown for the Southern Basin on the Murray River at Euston (dark blue) and for the Northern Basin on the Darling River at Burke (light blue), with averages shown as dotted lines. Source: MDBA, 2017.[11]

This Agreement, together with the Commonwealth's post-war nation-building agenda, shaped the course of water management through the mid-20th century. The Snowy Mountains Hydro-Electric Scheme constructed from 1949 to 1974 was the largest engineering project in Australia. It employed 100,000 workers in regional communities, of which 65% were immigrants. Governments also invested in the expansion of irrigation into the dry inland plains. By 1988, 84 large dams and weirs had been built in the Basin for regulating the river for water supply, river navigation, flood mitigation and hydro-electricity.[12] Thousands of small dams were constructed on farms for private use, and levees and channels were built to transport water to farms. This infrastructure provided for the rapid expansion of irrigated agriculture. Water use more than doubled in the period between the 1950s and the 1970s, and continued to grow steadily through the 1990s (Figure 3). In 1998, about one third of the annual inflow into the Basin was extracted for irrigation each year, an amount that was approaching the average annual natural flow to the sea (Figure 3).[12]

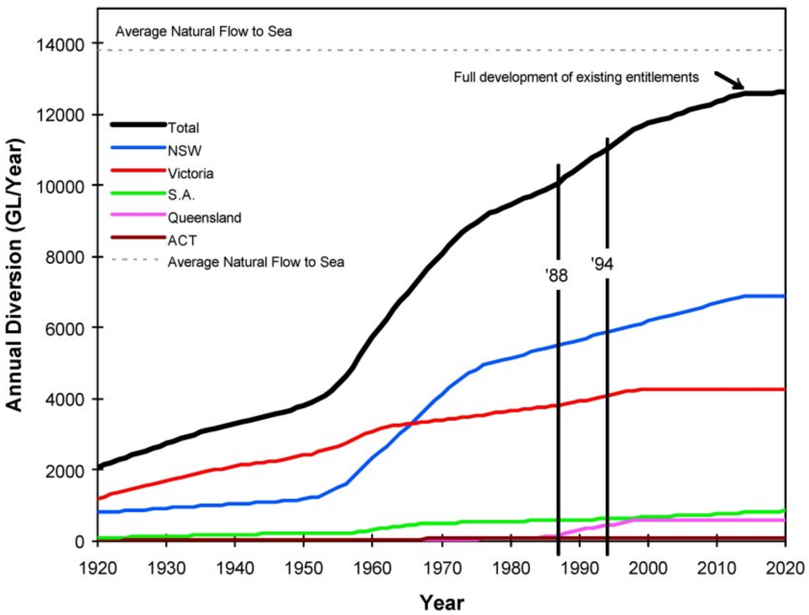

Figure 3. Annual diversions in the Murray-Darling Basin. Source: MDB Ministerial Council, 1995[13]

The 1918 Agreement proved adequate during the period of expansion and growth, but in drier years it failed to manage the problems of water quality. During the 1960s and 1970s, dryland salinity emerged as a problem, prompting investigations into salinity across the Basin. By 1987 it was estimated that 96,000 hectares of the Basin's irrigated land were salt-affected and 560,000 hectares had water tables within two metres of the land surface.[14] The Murray mouth closed for the first time on record in 1981, and dredging commenced to manage salt concentrations in the Coorong. In recognition of these issues, the Murray-Darling Basin Agreement was expanded to address water quality issues in 1987.

The problem of over-allocation of rivers remained. In 1991, a 1,200km blue-green algae bloom formed in the warm, shallow waters of the Darling River. An audit of water use by the Murray-Darling Basin Commission in 1995 revealed that median annual flows through the Murray mouth were only 21-28% of what they would have been in natural conditions.[15] It also found that drought conditions in the lower Murray occurred in 60% of years compared to 5% under natural conditions. In most years, water was so over-allocated, that more water was permitted to be taken than was physically available in the rivers. In 1997, after a century of unrestricted growth in water use, the Commission agreed to place a cap on water diversions from the Murray-Darling Basin.

The millennium drought (1999 to mid-2010) was the next shock to the system. Record low flows caused widespread degradation of the environment across the Basin, hyper-salinisation of the Coorong and Lower Lakes region in South Australia, and the closure of the Murray mouth. Only 2 of the 23 valleys of the Basin remained in moderate to good health by the end of the decade (Figure 4).[16] The impacts had flow-on effects for communities and the regional economy. One in every five jobs in agriculture across the Basin were lost from 2001 to 2011.[17] The crisis of the millennium drought prompted a new generation of water reforms designed to protect the health of rivers, wetlands, estuaries and groundwater systems while securing water supply for people and their livelihoods.

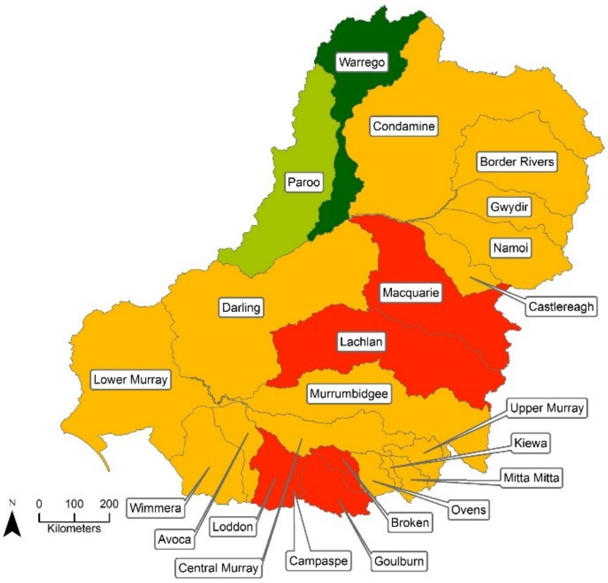

Figure 4. Ecosystem health as reported in the Sustainable Rivers Audit 2, showing valleys in good (dark green), moderate (light green), poor (yellow) and very poor (red) health (2008 - 10).

In the past two decades, governments have responded to these challenges by setting a new agenda for managing water in the Murray-Darling Basin. They have embarked on a series of water reforms aimed at protecting and restoring the health of Australia's rivers, wetlands, estuaries and groundwater systems, in a way that also creates economic opportunities and prosperity for communities in the Basin. The historic *National Water Initiative* in 2004 was described by many at the time, including the Wentworth Group, as one of the most significant agreements in our nation's history. The solution rested on the creation of more wealth using less water, by securing property rights for water users and promoting trade of water to higher value uses, in exchange for restoring over-allocated rivers to sustainable levels of extraction.

On Australia Day in 2007, Prime Minister John Howard announced at the National Press Club a ten billion dollar *National Plan for Water Security* to "once and for all" address over-allocation of water in the Murray-Darling

Basin.[18] In that same year, the then Minister for Environment and Water, Malcolm Turnbull introduced the *Water Act 2007* which set a legislative framework for water planning and management through what amounted to a $13 billion public investment package. In introducing the Water Bill 2007 to Parliament, Minister Turnbull announced "for the first time, the governance of the basin will reflect the hydrology of the basin—one interconnected system managed for the first time in our history in the national interest… We need these reforms to ensure the viability of our water-dependent industries, to ensure healthy and vibrant communities and to ensure the sustainability of the basin's natural environment". The *Water Act 2007* set the foundations for the Murray-Darling Basin Plan which was the key policy for returning a sustainable balance to the Basin. The *Water Act* 2007 also established the Commonwealth Environmental Water Holder tasked with managing the portfolio of environmental water, of what will amount to a quarter of entitlements in the Basin.[19]

The Murray-Darling Basin Plan

The Commonwealth *Water Act 2007* stated that the purpose of the Murray-Darling Basin Plan is to provide for the integrated management of the Basin's water resources by restoring an environmentally sustainable level of take while optimising economic, social and environmental outcomes. The Murray-Darling Basin Authority is required to prepare a Basin Plan which provides for the purposes summarised below:

a) Giving effect to relevant international agreements, including the Ramsar Convention on Wetlands (shown in Figure 5);
b) Establishment and enforcement of environmentally sustainable limits on the quantities of surface water and groundwater that may be taken (including by interception activities);
c) Basin-wide environmental objectives for water-dependent ecosystems, and water quality and salinity objectives;
d) Use and management of water resources in a way that optimises economic, social and environmental outcomes;
e) Water to reach its most productive use through the development of an efficient water trading regime across the Murray-Darling Basin;
f) Requirements that a water resource plan must meet if it is to be accredited or adopted; and
g) Improved water security for all uses of water resources.[20]

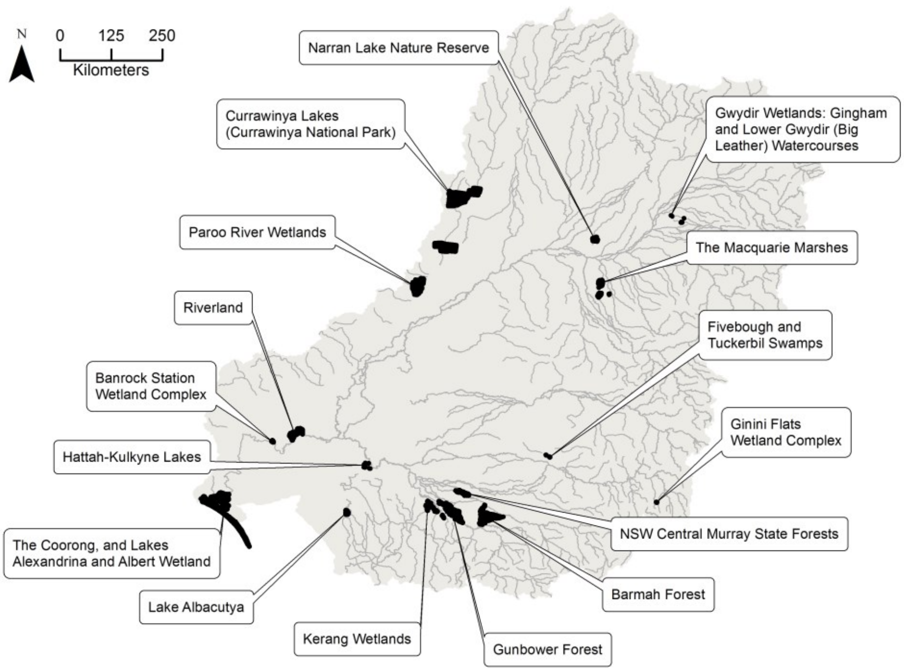

Figure 5. Location of the sixteen Ramsar wetlands in the Murray-Darling Basin.

With respect to the "establishment and enforcement of environmentally sustainable limits on the quantities of surface water and ground water that may be taken from the Basin water resources", the best available evidence produced by the Murray-Darling Basin Authority in 2010 suggested that achieving environmentally sustainable level of extractions would require the recovery of between 3,856 GL (high uncertainty) and 6,983 GL (low uncertainty) of surface water from an annual consumptive use of 13,623 GL.[21]

In 2012, the Authority's Board rejected this advice and instead put to the Australian Government a Basin Plan to recover 3,200 GL of surface water or 'equivalent' outcomes while providing for an increase in groundwater extractions across the Basin by 1,548 GL.[22] This figure was later revised down to 949 GL in the final Basin Plan.[23] In other words, on the evidence provided by the government's own Authority, the reduction amount grossly underestimated the environment water requirements needed.[24] In addition, the Basin Plan also failed to incorporate the impact of increasing groundwater extractions, and did not take sufficient account of the risks to river health from climate change.[24]

While the recovery targets in the Basin Plan failed to meet the minimum requirements for a healthy basin, the Wentworth Group recognised that the Authority's modelling demonstrated that recovery of 3,200 GL or equivalent was capable of producing a substantive improvement in the health of the river system, provided groundwater extraction does not impact on river flows, environmental flows are protected, and river management constraints impeding flows to target wetlands are removed.[25]

The Murray-Darling Basin Plan was passed through Parliament on the 22 November 2012 as a disallowable instrument with bipartisan support and unanimous agreement from Basin states. The long-term annual limits on extractions, known as the sustainable diversion limits, will come into effect in 2019, and the Basin Plan will be reviewed in 2026. In December 2016, all Murray-Darling Basin First Ministers agreed "The Murray-Darling Basin is of vital economic and environmental significance to a large part of Australia and it is critical that the Basin Plan is implemented on time and in full".[6] The Wentworth Group has welcomed this statement.[26] We have also recognised the decision of the Australian Parliament to recover 3,200 GL of environmental water or equivalent outcomes even though this is not sufficient to achieve an environmentally sustainable level of extraction.

Objectives and outcomes of the Basin Plan

There are six categories of management objectives and outcomes to be achieved by the Basin Plan (Table 1). These include objectives and outcomes for the Basin Plan as a whole (s5.02 in Table 1), in relation to environmental outcomes (s5.03), in relation to water quality and salinity (s5.04), in relation to long-term average sustainable diversion limits (s5.05), in relation to the operation of the sustainable diversion limit adjustment mechanism (s5.06), and in relation to trading in the water market (s5.07).

Table 1. Objectives and outcomes of the Basin Plan, as set out in Chapter 5 of the Basin Plan.

Objectives	Outcomes
Section 5.02: Objectives and outcome for Basin Plan as a whole	
a) Give effect to relevant international agreements through the integrated management of Basin water resources (including the 16 Ramsar sites in the Basin; Figure 1); b) Establish a sustainable and long-term adaptive management framework for the Basin water resources, that takes into account the broader management of natural resources in the Murray-Darling Basin; and c) Optimise social, economic and environmental outcomes arising from the use of Basin water resources in the national interest; and	a) Communities with sufficient and reliable water supplies that are fit for a range of intended purposes, including domestic, recreational and cultural use; and b) Productive and resilient water-dependent industries, and communities with confidence in their long-term future; and c) Healthy and resilient ecosystems with rivers and creeks regularly connected

d) Improve water security for all uses of Basin water resources.	to their floodplains and, ultimately, the ocean.
Section 5.03: Objectives and outcome in relation to environmental outcomes	
a) Protect and restore water-dependent ecosystems of the Murray-Darling Basin; and b) Protect and restore the ecosystem functions of water-dependent ecosystems; and c) Ensure that water-dependent ecosystems are resilient to climate change and other risks and threats; and d) Ensure that environmental watering is co-ordinated between managers of planned environmental water, owners and managers of environmental assets, and holders of held environmental water.	a) Restoration and protection of water-dependent ecosystems and ecosystem functions in the Murray-Darling Basin with strengthened resilience to changing climate.
Section 5.04: Objective and outcome in relation to water quality and salinity	
a) Maintain appropriate water quality, including salinity levels, for environmental, social, cultural and economic activity in the Murray-Darling Basin.	a) Basin water resources remain fit for purpose.
Section 5.05: Objective and outcomes in relation to long-term average sustainable diversion limits	
a) establish environmentally sustainable limits on the quantities of surface water and groundwater that can be taken for consumptive use from Basin water resources, having regard to social and economic impacts, and in doing so: i) Inform environmental water recovery measures, including water purchasing and infrastructure that improves water use efficiency; and ii) Provide greater certainty for all water users, including in times of drought and low water availability; and iii) Provide time for water access entitlement holders and communities to transition and adjust to long-term average sustainable diversion limits.	a) Restoration and protection of water-dependent ecosystems and ecosystem functions in the Murray-Darling Basin; b) Well-informed water recovery measures, including water purchasing and infrastructure, enable a transition to long-term average sustainable diversion limits; and c) Greater certainty of access to Basin water resources; and d) Water access entitlement holders and communities of the Murray-Darling Basin are better adapted to reduced quantities of available water.
Section 5.06: Objective and outcome for operation of the SDL adjustment mechanism	
a) Adjust SDLs in a way that increases environmental outcomes while maintaining or improving social and economic outcomes.	a) A healthy and working Murray-Darling Basin that includes the outcomes specified in subsection 5.02(2).
Section 5.07: Objectives and outcome in relation to trading in the water market	
a) Facilitate the operation of efficient water markets and the opportunities for trading, within and between Basin States, where water resources are physically shared or hydrologic connections and water supply considerations will permit water trading; and b) Minimise transaction cost on water trades, including through good information flows in the market and compatible entitlement, registry, regulatory and other arrangements across jurisdictions; and c) Enable the appropriate mix of water products to develop based on water access entitlements which can be traded either in whole or in part, and either temporarily or permanently, or through lease arrangements or other trading options that may evolve over time; and d) Recognise and protect the needs of the environment; and e) Provide appropriate protection of third-party interests.	Creation of a more efficient and effective market that: a) facilitates water reaching its most productive use; and b) enhances the productivity and growth of water-dependent industries; and c) enables water-dependent industries to: i. better manage through extreme events under current climate variability; and ii. strengthen their capacity to adapt to future climate change.

The outcomes for key environmental components under the Basin Plan are described in the Basin-wide environmental watering strategy developed by the Murray-Darling Basin Authority in 2014. The strategy identifies the expected outcomes for river flows and connectivity, native vegetation, waterbirds and fish (Table 2). Additional 'enhanced' environmental outcomes are to be pursued under a Commonwealth program to recover 450 GL of environmental water (Schedule 5). These enhanced environmental objectives relate to salinity levels in the Coorong and Lower Lakes, water levels in Lake Alexandrina, an open Murray mouth, export of 2 million tonnes of salt, increasing barrage flows, watering of floodplains and outcomes in the Southern Basin.

Table 2. Expected outcomes of the Basin Plan after 2019 for key environmental components, as described in the Murray-Darling Basin Authority's Basin-wide environmental watering strategy.[27]

Component	Expected outcome
River flows and connectivity: Improved flow connections along rivers, and between rivers and their floodplains	1. Maintain base flows at least 60% of natural levels 2. Improve overall flow by 10% more into the Barwon–Darling, 30% more into the River Murray and 30–40% more to the Murray mouth which opens to the sea 90% of the time 3. Maintain connectivity in areas where it is relatively unaffected, between rivers and floodplains in the Paroo, Moonie, Nebine, Warrego and Ovens 4. Improve connectivity with bank-full and/or low floodplain flows by 30–60% in the Murray, Murrumbidgee, Goulburn and Condamine–Balonne, and by 10–20% in remaining catchments 5. Maintain the Lower Lakes above sea level 6. Adequate flushing to export an average 2 million tonnes of salt from the River Murray system into the Southern Ocean each year
Native vegetation: Maintain the extent and improve the condition of native vegetation in the Murray-Darling Basin.	7. Maintain the current extent of about 360,000 hectares of river red gum, 409,000 ha of black box, 310,000 ha of coolibah forest and woodlands, existing large communities of lignum, and non-woody communities near or in wetlands, streams and on low-lying floodplains 8. Maintain the current condition of lowland floodplain forests and woodlands of river red gum, black box and coolabah 9. Improve the condition of southern river red gum
Waterbirds: Maintain current species diversity, improve breeding success and numbers.	10. Maintain current species diversity of all current Basin waterbirds and current migratory shorebirds at the Coorong 11. Increased abundance of waterbirds by 20–25% by 2024 12. Improved breeding with up to 50% more breeding events for colonial nesting species and a 30–40% increase in nests and broods for other waterbirds
Fish: Maintain current species diversity, extend distributions, improve breeding success and numbers.	13. Improved distribution of key short and long-lived fish species across the Basin 14. Improved breeding success for short-lived species (1–2 years), long-lived species in at least 8/10 years at 80% of sites, mulloway in at least 5/10 years 15. Improved populations of short-lived species (numbers at pre-2007 levels), long-lived species (with a spread of age classes represented), Murray cod and golden perch (10–15% more mature fish at key sites) 16. Improved movement with more native fish using fish passages

Aim of the review

It is now ten years since the Water Act was passed, and five years since the Basin Plan was adopted by the Australian Parliament. The aim of this review is to assess progress in implementing the Basin Plan to date and identify the actions necessary to deliver the Basin Plan as approved by Parliament in 2012.

The Australian Parliament has committed to spending $13 billion of taxpayers money to deliver the Basin Plan objectives including the 16 outcomes specified in Table 2. So far, $7.9 billion has been spent to recover 2,107 GL, leaving $5.1 billion to deliver the remaining 1,093 GL or equivalent.

Given the scale of investment and the impacts of these reforms, there is significant public interest in and scrutiny of the outcomes. Governments are ultimately responsible for ensuring the highest net returns to the community and demonstrating the tangible benefits of these reforms to the public.[28-30]

This review by the Wentworth Group documents progress towards the Basin Plan objectives and outcomes, using evidence of the environmental, economic and social changes that have occurred in past decades following recent water reforms and broader drivers. The review has two main components:

1) Measuring progress towards Basin Plan objectives and outcomes; and
2) Actions necessary to deliver the Basin Plan 'on time and in full'.

Progress towards Basin Plan outcomes

Progress towards 3,200 GL water recovery or 'equivalent'

As at September 2017, 2,107 GL of surface water entitlements have been recovered for the environment, representing 66% of the 3,200 GL target. Water recovery targets consist of local targets which specify the volume of water to be recovered within a valley, and shared targets which specify the volume of water to be recovered across multiple valleys. Nearly all local targets have been achieved (99%; Figure 6) and less than half of the shared targets have been achieved (44%; Figure 7). See Appendix 1 for more information on progress towards water recovery targets.

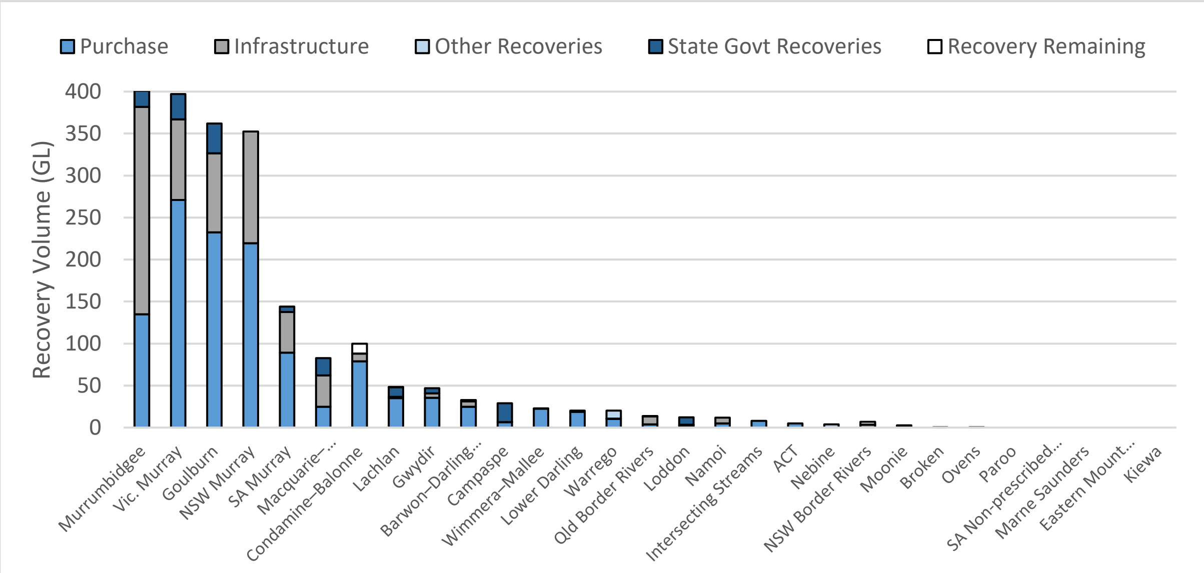

Figure 6. Surface water recovered towards local reduction targets within valleys of the Murray-Darling Basin as of 30 September 2017. White bars show recovery still required to reach target.[31]

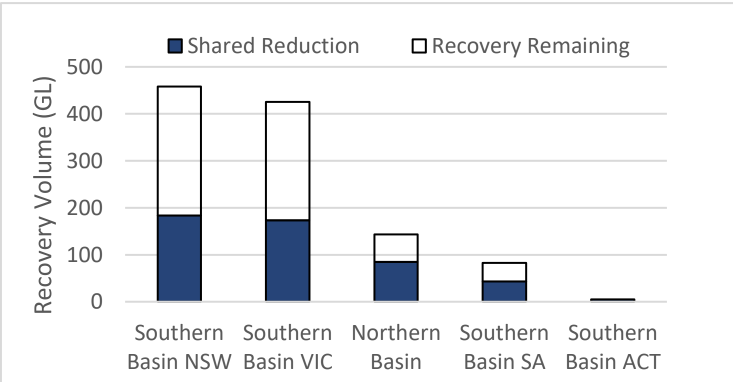

Figure 7. Surface water recovery towards shared reduction targets within zones of the Murray-Darling Basin as of 30 September 2017.[31] *White bars show recovery still required to reach target.*

Most of the surface water recovery has occurred in the Murrumbidgee, Murray and Goulburn rivers in the southern Murray-Darling Basin. A total of 1,093 GL of water recovery or equivalent outcomes is still required to achieve the 3,200 GL target in the Condamine-Balonne, Border Rivers in New South Wales and the Lower Darling. Nearly two thirds (63%) of all water acquired to date was recovered through direct purchase of entitlements. The remainder was recovered through infrastructure upgrades (Figure 6).

Three quarters of all surface water recovered to date occurred before the Basin Plan was enacted in 2012 (1,577 GL).[32] Progress slowed considerably after the Basin Plan was adopted, and has subsequently reduced to a trickle (Figure 8).

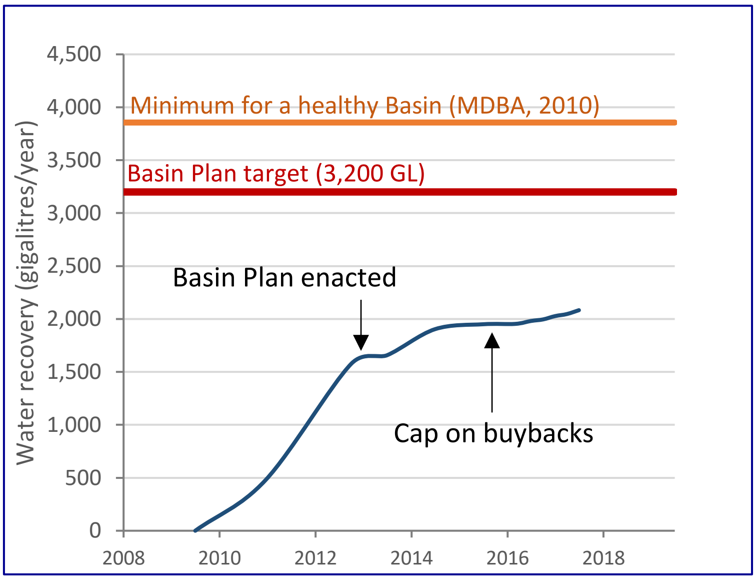

Figure 8. Progress on water recovery (blue line) towards the Basin Plan target (red line). The orange line shows the minimum amount of water required for a healthy Basin.[21] (Source: SEWPAC, MDBA and DAWR records, 2012 – 2017)[33-38]

Only 530 GL has been acquired in the past five years. None of the 450 GL of 'up-water' for outcomes in the Lower Murray, Lower Lakes and Coorong has been recovered under a $1.77 billion Commonwealth program funded through the Water for the Environment Special Account. South Australia is conducting a pilot test of projects that meet the objectives, but progress made by other states is unknown. Slowing of progress on water recovery coincided with a major policy shift by the Commonwealth Government in 2014 which prioritised infrastructure upgrades over water purchase.[39]

In addition to surface water limits, the Basin Plan sets long-term limits on groundwater extractions. Groundwater extractions are within these limits in 20 of the 21 groundwater resource units. The Central Condamine Alluvium is the only groundwater resource unit which requires a reduction in the long-term diversions under the Basin Plan. So far, only 6.7% of the groundwater target has been recovered from this unit (2.7 GL of the 40.4 GL; Figure 9).[38]

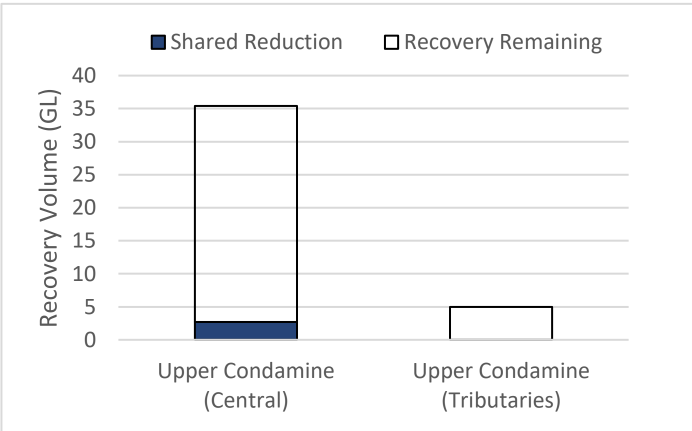

Figure 9. Groundwater recovery towards reduction targets within areas of the Murray-Darling Basin as of 30 September 2017.[31] White bars show recovery remaining to reach groundwater target.

Expenditure on water reform

The Australian Government is providing around $13 billion for implementation of the Murray-Darling Basin Plan and associated activities. Of this, $4.9 billion is for on- and off-farm irrigation efficiency projects, $3.1 billion is committed to water purchase, $1.6 billion is for efficiency measure projects to deliver enhanced environmental outcomes, $1.3 billion is committed to supply measures, $200 million is for constraints and the remainder is to fund a range of state and Commonwealth projects (Table 3).

More than half of this funding has already been spent ($7.9 billion; Table 3). Of this, nearly half has been spent on infrastructure projects ($3.6 billion), one third has been spent on water purchase ($2.7 billion) and the remainder has been spent on other activities.

Table 3.Commonwealth expenditure on water reform (as at 30 September 2017). Data provided by the Department of Agriculture and Water Resources.

Program	Component	Commitment ($b)	Expenditure ($b)
Sustainable Rural Water Use and Infrastructure Program (SRWUIP)	Infrastructure (MDB)	4.9	3.6
	Water purchase	3.1	2.7
	Supply measures	1.3	0.03
Enhanced Environmental Outcomes *(Water for the Environment Special Account)*	Efficiency Measures	1.6	0.01
	Constraints	0.2	
South Australian River Murray Sustainability Program		0.3	0.2
South Australian Riverland Floodplains Integrated infrastructure Program [1]		0.2	0.06
Murray-Darling Basin Regional Economic Diversification Program [1]		0.1	0.1
The Living Murray Initiative [1]		0.2	0.2
Other Basin-related activities [2]	Various	1.1	1.0
Total		**13.0**	**7.9**

[1]Where programs are delivered by other agencies, expenditure is reported as per the original funding profile when funding was transferred to the relevant agency. Refer to Portfolio Budget Statement or website of relevant agency for information on the status of the program.
[2]Other Basin related activities include, but is not limited to a part of the funding within Water Smart Australia, Murray Environmental Flows (Water for Rivers), South Australia Bioremediation and revegetation, Basin Plan activities and Hume Dam remedial works.

In 2014, expenditure priorities shifted from water entitlement purchase to investment in infrastructure projects (Figure 10). The average cost of water recovery using infrastructure upgrades ($5,100 per megalitre) was double that of water recovery through purchase of entitlements ($2,200 per megalitre) between 2007-08 and 2015-16.[40] Individual projects cost between 2 and 7 times more than direct purchase of equivalent quantities of water.[39]

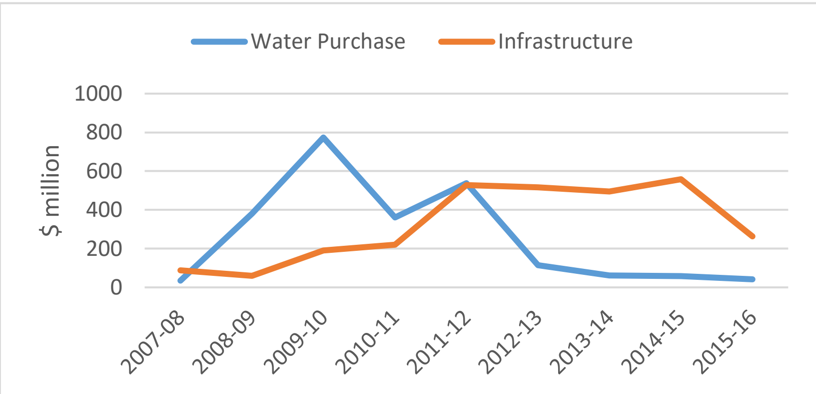

Figure 10. Commonwealth expenditure in the Murray-Darling Basin, 2007-08 to 2015-16.[41]

Progress towards Basin Plan objectives

We evaluated progress towards the management objectives to be achieved by the Basin Plan (Table 4). These include objectives and outcomes for the Basin Plan as a whole (s5.02 in Table 1), in relation to environmental outcomes (s5.03) including enhanced environmental outcomes (Sch 5), in relation to water quality and salinity (s5.04), and in relation to long-term average sustainable diversion limits (s5.05) and in relation to the operation of the sustainable diversion limit adjustment mechanism (s5.06). We did not report on progress towards objectives related to trading in the water market.

Table 4. Summary of progress towards Basin Plan objectives.

Objective	Progress
(s5.02) Objectives for the Basin Plan as a whole	
5.02 (1) (a) Give effect to international agreements	At the most recent 2015 Ramsar Convention, the Australian Government reported that ecological character had improved for 3 Ramsar wetlands, remained unchanged for 12 wetlands, and declined for one site, the Riverland, since the last triennium report in 2012.[42] While localised improvements have been made in some wetlands, e.g. in the Gwydir wetlands, Ramsar sites remain in a state that is more degraded than the ecological character for which they were listed under the treaty. Vegetation condition assessments by the Murray-Darling Basin Authority in 2015 show that less than a third of the area of red gum and black box forests across surveyed sites was in good condition, and the area of forests in degraded or severely degraded has increased (Figure 26).[43] The Coorong and Lower Lakes had improved in condition following the adverse changes to the ecosystem reported to the Ramsar Convention in 2010,[44-46] however "the Basin Plan is unlikely in the longer-term to maintain the ecological character of the [… Coorong, Lower Lakes and Murray mouth] Ramsar site".[47] The Wentworth Group did not assess the condition of other wetlands nor assets protected under other international agreements.
5.02 (1) (b) Establish adaptive management framework	Many of the key elements for an adaptive management framework and its implementation are already well established in the Basin Plan and related documentation, including measurable outcomes[27], a conceptual river model,[48] and a legislated requirement to review the Basin Plan on a recurring basis. Further work is needed in a number of areas including reaching consensus on shared management objectives, monitoring outcomes of reforms, preparing climate change responses and integrating natural resource management measures with flow management.
5.02 (1) (c) Optimise social, economic and environmental outcomes	An optimal social, economic and environmental reform requires first securing the water resources in the national interest, then assisting those who are likely to be most impacted to adapt to these changes. The Murray-Darling Basin Authority's approach to optimising social, economic and environmental outcomes[49] is based on a flawed assumption that a healthy Basin comes at the cost of jobs. This is not the case when water recovery is undertaken in concert with a regional development package to assist impacted communities.
5.02 (1) (d) Improve water security	The Murray-Darling Basin Authority reported that annual diversions in all valleys where a cap was defined have complied with the surface water diversion targets from 2011-12 to 2015-16 water years, with exception of the Queensland Moonie valley which was exceeded in 2014–15 and 2015–16.[33-35] However, Water Audit Monitoring reports and Independent Audit Group reports on cap implementation have not been published since 2011-12, so the accuracy of the assessments is not known (see page 48). We identified risks to water resources that may affect the security of water allocations for users: protection of environmental flows, growth in consumptive use and climate change (see pages 56 and 68).
(s5.03) Environmental outcomes	
5.03 (1) (a) Protect and	Environmental water monitoring reports by the Commonwealth and state governments have reported measurable improvements for vegetation, fish, waterbirds and a number of

restore water-dependent ecosystems	other environmental attributes for surveyed valleys where environmental flows have been delivered (see Appendix 2). However the condition of water-dependent ecosystems has not improved across the Basin as a whole (see page 30 for more detail).
5.03 (1) (b) Protect and restore ecosystem functions	Nearly all environmental watering flows delivered between 2013 and 2015 reported positive outcomes for flow variability and connectivity. However at a Basin scale, the recent State of the Environment report rated ecological process as 'very poor' with a "widespread loss of ecosystem function" although little detail was provided.[50] Some environmental watering events in the period between 2013 and 2015 were limited by physical and policy constraints.
5.03 (1) (c) Resilience to climate change and other threats	Climate change was not incorporated into the assessment of sustainable diversion limits for the Basin Plan, nor has climate change been considered in subsequent reviews (e.g. Northern Basin review).[51] While improvements in water quantity and quality expected under the Basin Plan could enhance the capacity of some species to adapt, migrate or cope with climate change and other risks, these outcomes are not guaranteed to be sufficient to support the long-term resilience of the Basin's ecosystems.
5.03 (1) (d) Coordinate environmental watering	There was some evidence of coordination among environmental water holders, with 1 in every 5 events undertaken by two or more jurisdictions.[52] Nearly all watering events reported between 2013 and 2015 aligned with Basin annual environmental watering priorities.[52] Constraints to river flows, which are becoming worse in some areas, pose challenges for coordinating environmental watering. For example, operators are not able to coordinate environmental watering events into South Australia because of upstream constraints to flow delivery between Yarrawonga and Wakool junction.
(Sch 5) Enhanced environmental outcomes[53]	
Sch 5 (2) (a) Reducing salinity levels in Coorong and Lower Lakes	Salinity levels in Lake Alexandrina at Milang have remained below 1,000EC since 2012 (Figure 23), although they came close to this threshold in the dry winter of 2016. Salinity targets were achieved for the 2015-16 reporting year,[54] but not for the years 2013 to 2015 due to the influence of the millennium drought on 5-year average calculations. Historically, salinity levels in the Coorong South and North Lagoons have exceeded the target figures.[55] Scenario modelling by Lester *et al.* 2013[56] showed salinity was up to 8 times that of seawater in the South Lagoon.[56] The South Coorong was in an unhealthy hypersaline state up to 10 times more frequently under the dry scenario compared to historical climate.[56]
Sch 5 (2) (b) Water levels in Lake Alexandrina	Water levels in Lake Alexandrina have remained within the target range since the Basin Plan was implemented in 2012, with the exception of a few short periods where water level fell below 0.4 metres AHD (Figure 23).
Sch 5 (2) (c) Open Murray mouth	After the 2010 floods, barrage flows increased and dredging was not required to maintain an open Murray mouth for 4 years. However, during this period, sand continued to accumulate at the mouth, requiring the reintroduction of dredging in late 2014. A flood event in spring 2016 saw the removal of dredging operations, only to be reinstated in January 2017. Even when the Basin Plan is fully implemented, the objective that the "mouth of the River Murray is open without the need for dredging in at least 95% of years"[57] will not be possible to achieve without significantly more river flow, permanent dredging and/or other major interventions (see page 63).
Sch 5 (2) (d) Export of 2 million tonnes of salt	This outcome has been met in 1 of the 3 reporting periods (2012-2014 and 2013-2015, not 2011-2013), based on a 3-year rolling average estimated by the Murray-Darling Basin Authority.
Sch 5 (2) (e) Increasing barrage flows	There is no coherent plan or action documented in the Basin Plan for the management of water levels in Lake Alexandrina for periodic flushing of lake water into the North Coorong and then the South Coorong. Any advances in this regard are further threatened by

	jurisdictional efforts to increase the permitted level of take by increasing sustainable diversion limits.
Sch 5 (2) (f) Watering of floodplains	Watering events remained largely in-channel, particularly in the southern Basin, or were diverted onto floodplains using engineering works. Stronger effort will be needed to address physical and policy constraints that have limited overbank environmental watering in the Basin.
Sch 5 (2) (g) Outcomes in Sth Basin	The condition of the Riverland / Chowilla wetlands is a key indicator for judging progress. The Australian Government's 2015 national report on the implementation of the Ramsar Convention reported that the ecological character had declined for the Riverland since the last triennium report.[42] Deterioration in the ecological character status of the Riverland region was attributed to changed hydrologic regime and changing climate.[58] We note that 'upper' floodplains, particularly those in South Australia, are excluded from this outcome and are at risk of becoming terrestrial ecosystems.
(s5.04) Water quality and salinity	
5.04 (1) Maintain appropriate water quality, including salinity	Salinity targets were met in four out of five locations in the southern Basin for the 2011 to 2016 reporting period.[10] Targets were not met at the end of the Darling River in Burtundy due to low flows. Around 525,000 tonnes of salt were diverted from the River Murray in 2015–16 through salt interception schemes.[59]
(s5.05) Long-term average sustainable diversion limits	
5.05 (1) Establish SDLs for surface and groundwater	Surface water recovery has progressed with 2,107 GL of the 3,200 GL Basin-wide recovery target acquired as of September 2017. Nearly all local recovery has been achieved (97%), however progress towards shared targets is poor (35%).[60] Only 6.7% of the groundwater target has been recovered (2.7 GL of the 40.4 GL),[38] from one groundwater zone, the Central Condamine Alluvium.
(s5.06) Operation of the SDL adjustment mechanism	
5.06 (1) Adjust SDLs	In 2017, states agreed on a package of 37 supply measure projects to be considered for SDL adjustment and 2 efficiency measure projects. We found that only one supply measure proposal satisfied the Basin Plan requirements, 25 did not satisfy the Basin Plan requirements and 11 projects required further information for assessment (see page 51 for results). Efficiency measure projects were listed by Basin states, however no water has been recovered towards the 450 GL through efficiency measures to date.

Progress towards social, economic and environmental outcomes

The outcome for the Basin Plan as a whole is to deliver a "healthy and working Murray-Darling Basin" (Basin Plan s5.02) that includes:

a) "Communities with sufficient and reliable water supplies that are fit for a range of intended purposes, including domestic, recreational and cultural use;
b) Productive and resilient water-dependent industries, and communities with confidence in their long-term future; and
c) Healthy and resilient ecosystems with rivers and creeks regularly connected to their floodplains and, ultimately, the ocean."

Evidence of progress towards these outcomes has been documented and summarised in the following sections. The extent to which the Basin Plan will contribute to overall long-term outcomes will become apparent over coming years as the Basin Plan is implemented fully, monitoring and reporting on Basin Plan targets is completed, and lag effects play out across the Basin. It will also depend on how we address challenges and risks that could affect the achievement of Basin Plan outcomes, such as protection of environmental water and management of climate change impacts (see pages 56 and 68).

Outcome 1: Communities with sufficient and reliable water supplies

An outcome of the Basin Plan as a whole is "communities with sufficient and reliable water supplies that are fit for a range of intended purposes, including domestic, recreational and cultural use".[61] Central to this outcome is that water is of sufficient quality, quantity and reliability for water users.

QUALITY

Most water quality reporting focuses on salinity, but sedimentation, excess nutrient loads, hypoxic blackwater and algal blooms also affect the quality of water supply for communities. Average salinity targets were met in four out of five locations in the southern Basin for the reporting period from 2011 to 2016.[10] The target was not met at the end of the Darling River for this period due to low flows. Nearly 1 million tonnes of salt was exported out of the Basin each year from 2012 to 2015 on average, more than would have been exported without the Basin Plan but less than the Basin Plan objective of 2 million tonnes per year. This objective has been met in only 1 of the 3 reporting periods, based on a 3-year rolling average (Table 5),[62] due to low inflows into the River Murray system over the reporting period.

Table 5. Achievement of salt export objective for three reporting periods.[62]

Reporting period	Basin Plan outcome (tonnes)	Observation (tonnes)	Outcome met
Jul 10 – Jun 13	2 million	~2.9 million	Yes
Jul 11 – Jun 14	2 million	1.5 million	No
Jul 12 – Jun 15	2 million	0.9 million	No

Salt interception schemes have been used in conjunction with flows to manage water quality, by concentrating saline water for discharge into groundwater or for harvest as crystals. Around 525,000 tonnes of salt were diverted from the River Murray in 2015–16 through salt interception schemes.[59] The Commonwealth government expects the schemes will be viable over the next 15 years.[63] However, interception schemes may not be configured to mitigate future salt loads, given the potentially large projected increases in the century ahead.[64] Sufficient freshwater flow and an open Murray mouth are therefore essential to meeting the Basin Plan's long-term objective for the export of 2 million tonnes of salt each year.

QUANTITY

The volume of water allocations and diversions for water users is highly variable (Figure 11).[65] There was a steady decline in diversions from 1997-98 to 2008-09. The volume of water allocation had halved by the end of this period. Drought-breaking floods of 2010-11 resulted in surface water allocations across the Basin reaching a record high, then subsequently decreasing as rainfall decreased in the Basin. Surface water diversions followed a similar pattern to allocations. Diversions increased after the millennium drought to pre-drought levels, before falling again by about a third to 2014-15. Since 2012, water users have diverted more than three quarters of their allocation each year.

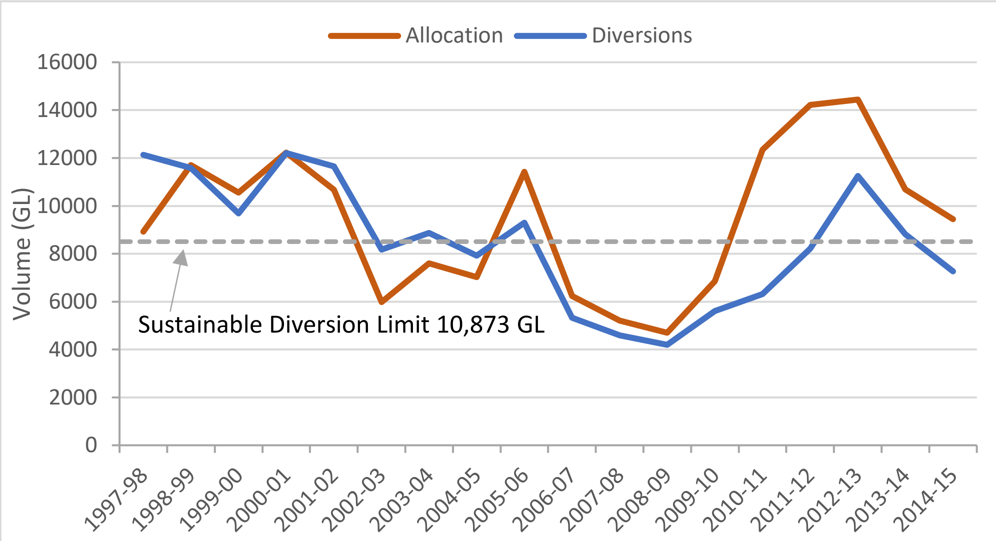

Figure 11. Total water allocations and diversions of surface water for water users in the Murray-Darling Basin (MDBA, 2016).[66]

Groundwater use appeared to be inverse that of surface water, with water users drawing greater volumes of groundwater during dry periods when surface water availability was low, while in wetter periods groundwater extraction decreased with increasing surface water availability. Groundwater use in the Basin reached levels of more than 1,500 GL during the millennium drought before decreasing by more than half during the wet period of 2010-11. Groundwater use returned to millennium drought levels by 2014-15 (Figure 12). These Basin-wide trends mask wider variations in water availability between valleys and entitlement types.

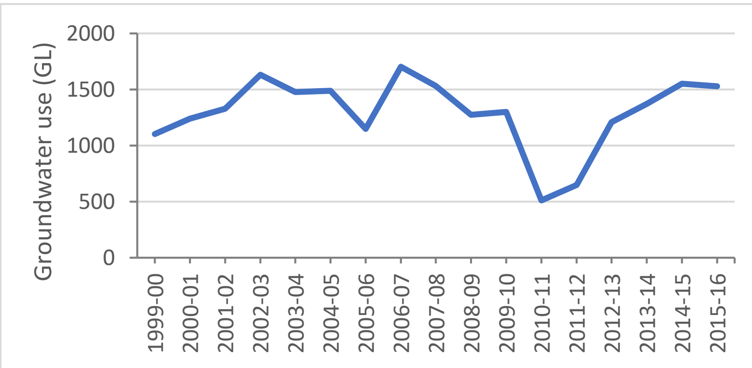

Figure 12. Total groundwater extracted in the Murray-Darling Basin from 1999-00 to 2015-16. The sustainable diversion limit for groundwater is 3,334 GL. Note: Groundwater data needs to be interpreted with caution. Source: MDBA Water Audit Monitoring Reports (1999-00 to 2011-12) and BOM National Water Accounts (2012-13 to 2015-16).[67]

RELIABILITY

The reliability of water entitlements in the Murray-Darling Basin is variable, driven by the high variability of river flows. The average annual inflow in the Murray-Darling Basin's rivers is 32,500 GL, but this amount has varied historically from less than 7,000 GL (in 2006) to almost 118,000 GL (in 1956).[11] This variability in water availability is reflected in the volume of water allocations and diversions for water users from 1997-98 to 2014-15 (Figure 11).[68]

Large dams have helped farmers to manage the reliability of water supply in highly variable river systems. For example, the Snowy Mountains scheme helps to manage the massive variation in water availability. There are now 93 major public storages in the Murray-Darling Basin with a combined capacity of 25,344 GL, or two thirds of the total annual inflow.[69] These storages allow water users to manage reliability by storing water over multiple years and calling on the desired volume of water at a required time.

Water trade and improved clarity of water entitlements since the National Water Initiative have also helped farmers to secure the appropriate level of reliability of water supply. Water entitlements with clearly defined characteristics (i.e. high security, general security and low security) allow water users to manage their water portfolio according to the supply reliability.

A key risk to reliability of water entitlements is the long-term changes in climate which could affect the volume of water available under water entitlements. The National Water Initiative seeks to assign risks arising from future changes in the availability of water. Under this framework, water access holders are to bear the risks of any reduction or less reliable water allocation as a result of changes in climate and natural events such as bushfires and drought (NWI Clause 48).

Outcome 2: Productive industries and communities with confidence in their future

To evaluate this outcome, the Wentworth Group commissioned an economist from the Australian National University to report on the status and trends of key socio-economic indicators in the Basin, and provide advice on the economic and social effects of water reform.[17] The report examined the changing nature of communities and industries in the Murray-Darling Basin and the possible drivers of these changes (Appendix 3). It documented changes in a number of key variables including the value of agricultural production, water use, water efficiency, employment and number of businesses for the Basin as a whole and for selected communities in the Basin. Statistical models were used to describe the likely causes of social and economic changes across the Basin.

ECONOMIC CHANGES IN THE BASIN

The Basin's economy has grown during the millennium drought and has been maintained in the period of water recovery under the Basin Plan (2009 – present). In 2014-15, the gross value of agricultural production in the Murray-Darling Basin reached a record high of $20,588 million, while in 2013-14 the gross value of irrigated agricultural production reached a record high of $7,135 million (Figure 13; nominal values). Long-term growth was interrupted by several years of decline in production during the millennium drought when water availability was half of pre-drought levels. Water recovery had a negative effect on irrigated agricultural production in the statistical model, however it did not have a significant influence on overall agricultural production.[17]

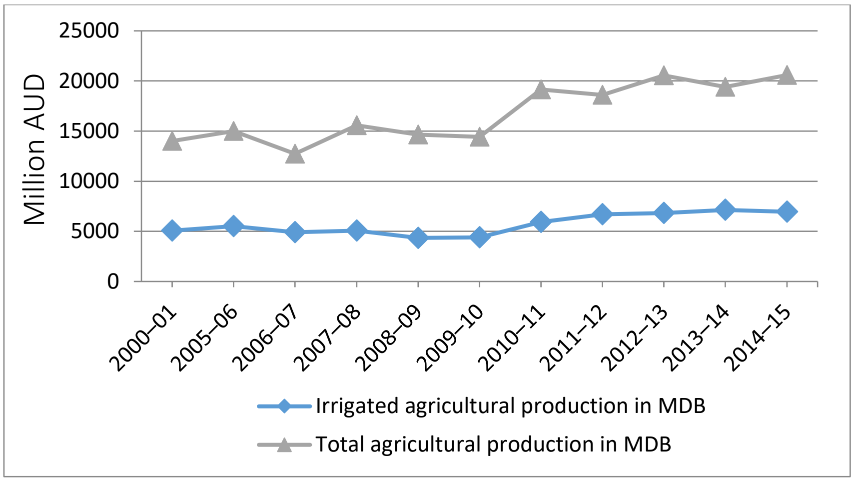

Figure 13. Gross value of irrigated and total agricultural production in the Murray-Darling Basin and Australia, in nominal values. Source: ABS, cat. No. 4610.0.55.008

Overall trends in economic indicators masked changes affecting some industries in the Basin. Since 2000, the cropping and dairy industries have experienced declines in total production while the horticulture and grazing industries have maintained production. Horticulture was sustained during dry periods using water from multiple sources including rainfall, allocations from reliable entitlements, and temporary trade from rice growers, mixed farmers and dairy.[70]

The 2004 National Water Initiative to return over-allocated systems to environmentally sustainable levels of extraction was part of a national imperative to increase the productivity and efficiency of Australia's water use.[7] To achieve these objectives, the National Water Initiative promoted the removal of barriers to trade to facilitate the transfer of water to higher value uses. Evidence since the National Water Initiative suggests that proportionally greater economic value is being derived with less water in drier periods. For example, despite more than a 70% decline in irrigated surface water applied during the drought from 2000-01 to 2007–08, the value of irrigated agricultural production fell by just 15% (Figure 14). As the Basin became drier again between 2012-13 and 2015-16, the value of irrigated agricultural production within the Basin was maintained despite a 40% decrease in water used for irrigation. Conversely, in wetter periods there was a tendency for water use to increase relative to production value: water use doubled from 2008-09 to 2011-12 but the gross value of irrigated production rose by only 30%.

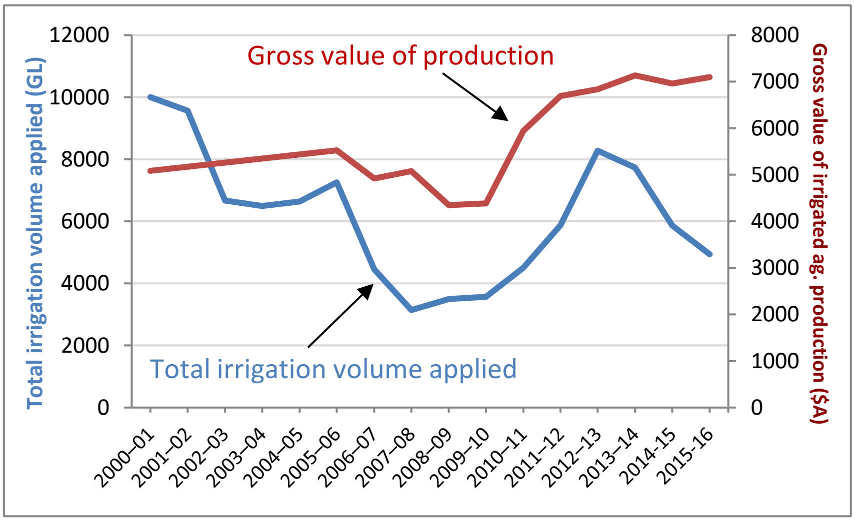

Figure 14. Total irrigation volume applied and gross value of production in the Murray-Darling Basin. Source: ABS, Water use on Australian farms, cat. No. 4618.0; ABS, Gross Value of Irrigated Agricultural Production, cat. No. 4610.0.55.008; MDBA Annual Report 2015-16.

The decoupling of water use from the value of agricultural production after 2012 was a result of multiple adjustments within the irrigation sector: a shift from higher to lower irrigation requirement crops, more efficient use of water in response to water scarcity, investment in on-farm productivity and water trade that allowed the highest value horticulture to stay in production while crops with lower marginal value and higher demand for water were fallowed.[71] These mechanisms, a central feature of the National Water Initiative, operated to greatly cushion the effects of reduced water availability during the drought and water recovery.

While some communities benefited from these reforms, others were adversely affected, partly because water was traded out of some districts and into regions where water use was more profitable. Overall, in the 11 years from 2004-05 to 2015-16, there was a 51% decline in the number of irrigation businesses in the Murray-Darling Basin. However, this decline was similar to the decline in the agricultural businesses outside the Basin (Figure 15), implying water prices or water recovery were not the driving factors of this decline. Communities such as Shepparton in Victoria and Griffith in New South Wales have experienced both population and economic growth, while others such as Deniliquin, Moree and Renmark have experienced declines in population and economic activity (see page 27).

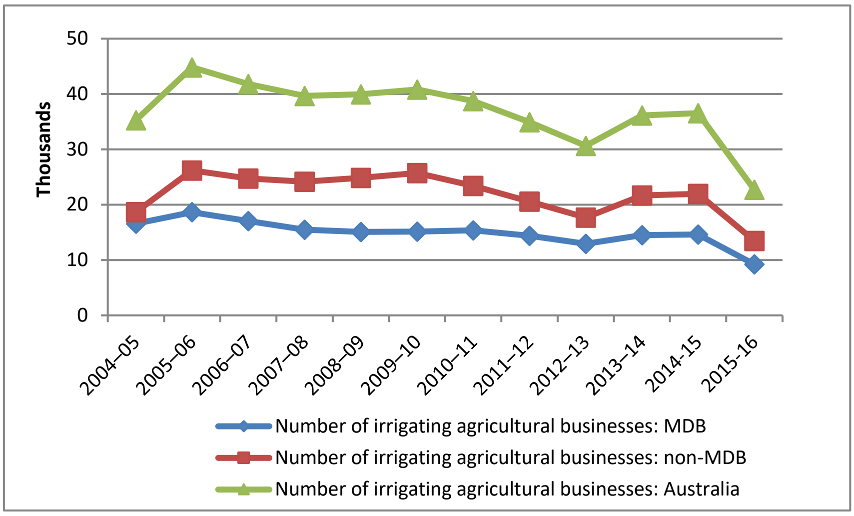

Figure 15. Number of irrigating agricultural businesses in the Murray-Darling Basin. Source: ABS, Water Use on Australian Farms, cat. No. 4618.0

OUTCOMES OF WATER REFORM FOR IRRIGATED AGRICULTURE

Irrigated agriculture has been a major beneficiary of water reforms in Australia. Windfall gains were made from the large transfer of water entitlements from public to private ownership during the reform process. A further $2.7 billion investment in acquiring water entitlements from willing sellers and a $3.6 billion investment in irrigation infrastructure modernisation has already provided irrigators in the Basin with a capital injection worth more than an average of $400,000 per irrigation business.[72] Of the $13 billion available for water reform, a total of $3.1 billion is to be spent on purchasing water entitlements, $4.9 billion of public funds allocated to on- and off-farm infrastructure modernisation and a further $1.6 billion is for projects to increase on-farm water efficiency. The total investment could reach more than $700,000 per irrigation business on average when the Basin Plan is delivered in full.[73] This is arguably the largest single structural adjustment program in Australian history.[74]

National water reforms since 2004 have brought a significant range of direct and indirect benefits to the irrigation industry. Economic benefits of public funds to purchase water from willing sellers included a pathway for exiting the industry, an opportunity to pay down debt and/or invest in more efficient infrastructure, as well as access to cash flow which helped farmers persist through the drought.[75, 76] A 2012 survey of 589 irrigators found that 60% of respondents had sold some water and kept farming, 30% sold all water and left farming, and 10% sold all water and continued farming.[77] Overall, half of the respondents who continued farming said selling water had no farm production consequences.[78]

Improvements in water markets as part of the reforms have also benefitted irrigators.[79,80] A survey of more than 4,000 farmers in New South Wales, Victoria and Queensland found that water trade has enabled better and more flexible responses to past and future droughts.[81] Water entitlement holders have also benefited from capital growth of water entitlements. Five years of growth in Aither's water price index for the southern Basin to a record high in June 2017 was attributed to dry conditions and strong demand from the irrigation sector.[82]

Economic benefits of infrastructure modernisation, subsidised by public funding, have included greater flexibility to manage drought risk and avoided costs for maintenance and renewal of infrastructure. Up to 50% of water savings returned to irrigators as part of the scheme has provided opportunities to expand production or sell surplus water on the temporary or permanent market.[71] Evidence is emerging of the potential for adverse short and long-term impacts of on- and off-farm irrigation upgrades and infrastructure modernisation.[83]

The innovations in water markets resulting from the National Water Initiative have promoted private sector innovation in not only managing water for irrigation but also for the environment. For example, the Balanced Water Fund is a $25 million water investment fund established in 2015 to provide water security for farmers while supporting the health of wetlands along the Murray River. Annual allocations are optimised by the fund managers, by trading water allocations on a 'counter-cyclical' basis. This means in dry years when water is scarce and irrigation demand is high, more water is made available to irrigators, while in wet years when water is more abundant and agricultural demand is lower, water is made available to floodplains and wetlands.[84]

While water markets have resulted in mainly positive economic outcomes, water trade can result in adverse consequences for downstream communities and the environment. In the Barwon-Darling River for example, water trade allows water entitlements to be traded among landholders regardless of the capacity of their on-farm storage. Current water management rules allow irrigators with larger storages to take advantage of elevated river levels as a result of environmental water as it passes downstream. Environmental water in these rivers are risk of being extracted for consumptive use.

One third (37%) of the gross value of agricultural production in the Basin is irrigated, the remaining 63% is from dryland crops including wheat and rainfed cotton and floodplain grazing.[17] Few other studies exist on the effects of water reform on these industries, as well as non-agricultural industries including tourism and fishing which are generally accepted as beneficiaries of water reforms.

Of the few studies of floodplain grazing available, one study showed that water recovery is expected to compensate for some impacts of upstream irrigation on floodplain graziers. Environmental flows under the Basin Plan can help to restore lost stocking rates by an estimated 25% and lost earnings by 28% depending on the location and type of water entitlements recovered.[85] Data also show that floodplain pastures rely on flooding, rather than rainfall, to stimulate the growth of pasture for livestock.[86] Cattle growth rates can triple for a short period following good winter flood events compared to average growth rates, while weight can be lost over the heat of summer or when cattle remain in the floodplains during extended dry periods, such as the 2001-02 drought.[86] Flooding in 1995 provided about $36.1 million in income from cattle, sheep and dry land farming for the 236 properties on the Lower Balonne floodplain in New South Wales.[87]

REGIONAL COMMUNITIES IN TRANSITION

Over the past few decades, the population and social structure of the Murray-Darling Basin has experienced significant shifts, with many communities facing an "undercurrent of steady decline".[88] Agriculture is one of the few industries in Australia experiencing long-term decline in employment (Figure 16). Nationally, employment in agriculture has declined by a third since 1960 (Figure 17). Today, agriculture employs 8% of all workers in the Basin.[17]

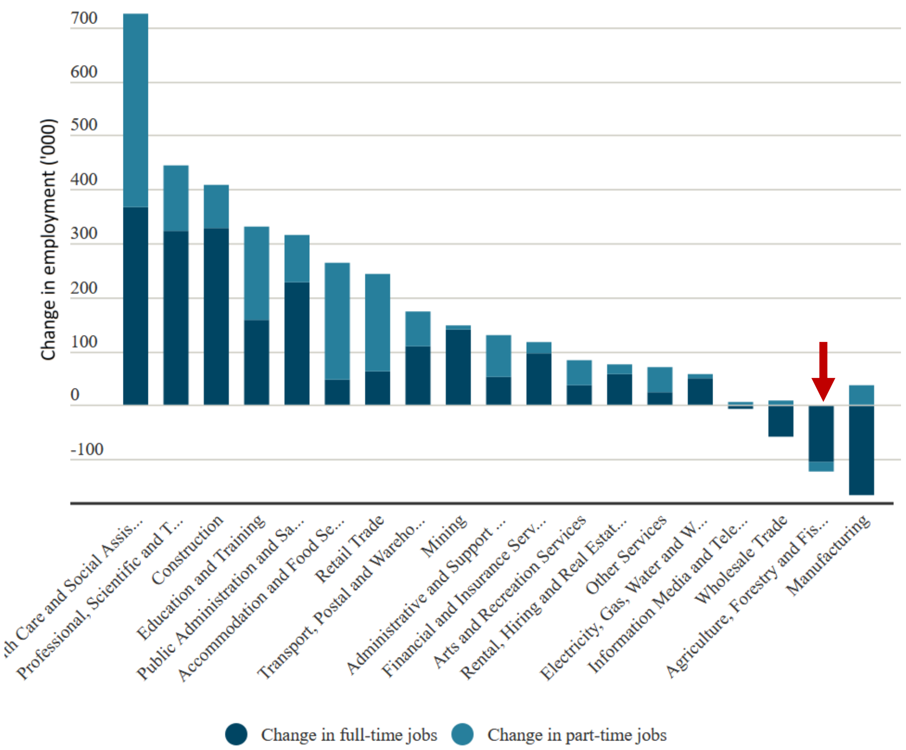

Figure 16. Australian job growth in the 21st century by industry of employment. Change (in '000) from Feb 2000 to Feb 2017. Source: ABS (catalogue 6291), published in The Australian 18 May 2017.

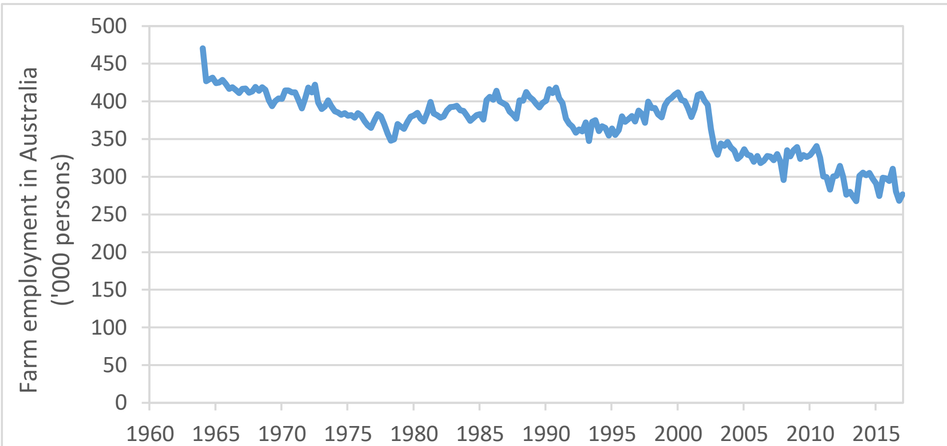

Figure 17. Farm employment (thousands of persons) in Australia since 1964. Source: ABS 2017.[89]

Between 2001 and 2016, employment in agriculture in the Basin has declined by 26% due to agricultural modernisation, commodity prices, drought, water policy and many other factors.[17] This decline slowed between 2011 and 2016 to -4%, while the nation-wide trend in agricultural employment grew by +4% over the same period. While total employment in agriculture has decreased, some sectors e.g. horticulture (plant/flower/seed growing) and beef cattle farming, have experienced an increase in employment in the past five years (Figure 18).

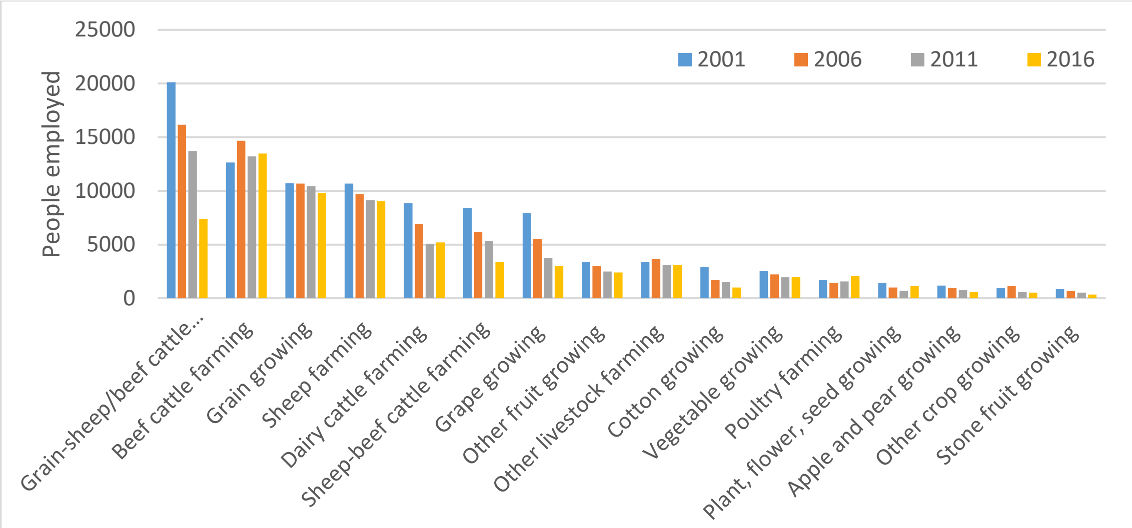

Figure 18. Trend in employment in agriculture in the Murray-Darling Basin. Source: ABS, Australian Census of Population and Housing 2001, 2006, 2011 and 2016.

The distinct shift away from employment in agriculture in the Basin has been balanced by growth in other sectors of the workforce. The number of people employed in Murray-Darling Basin has increased by 2% between 2011 and 2016, and by almost 8% over the period 2006 to 2016, largely due to increases in employment in other sectors such as education and training, health care and social assistance (Figure 19).

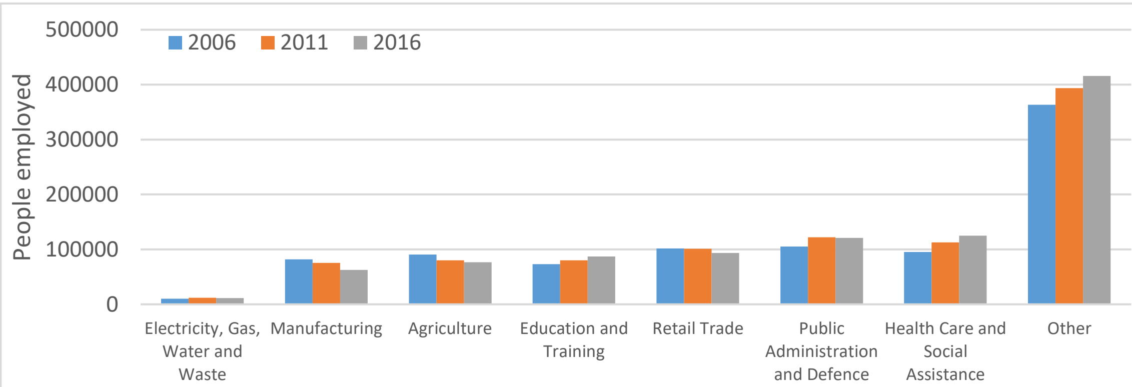

Figure 19. Trend in employment for sectors in the Murray-Darling Basin. Source: ABS, Australian Census of Population and Housing 2006, 2011 and 2016.

These Basin-wide changes have played out in rural and regional communities in diverse ways: some communities such as Shepparton in Victoria and Griffith in New South Wales have experienced both population, employment and economic growth, while others such as Deniliquin, Moree and Renmark have experienced declines in population and economic activity.[17]

In Griffith, for example, there was an increase of 17% in employment in agriculture between 2012 and 2015 following a 7-year decline as a result of the millennium drought. By 2015, Griffith's agriculture sector had fully recovered to pre-drought levels and agriculture employed the highest number of people of all reported sectors. Employment in the agriculture sector in Griffith increased by 42% between 2001 and 2015.

Strong growth in total employment in Shepparton from 2002 to 2007 reflected different structural changes in the local economy. Most growth occurred in services sectors including health care, construction and education. This growth outweighed a decline in employment in agriculture in Shepparton of 20% between 2001 and 2015.

Other regional centres have experienced significant declines in population and employment in agriculture. Deniliquin in southern New South Wales for example has experienced a drop in agricultural employment of 75% over the decade between 2003 and 2013. This is far greater than the national average. Over that period, the number of businesses almost halved, with agriculture/forestry/fishing businesses experiencing the most decline.

There are a number of reasons for the different trajectories of these Murray-Darling Basin towns and their associated districts. The 2007-08 drought seriously affected Deniliquin's rice industry, and this downturn exacerbated other pressures on the district including increased mechanisation of agriculture, and the closing of government agency offices in 2005. On the other hand, Griffith's population and employment increased over the same period, partly driven by the increase in local investment in the town. A younger population is attracted to Griffith due to large employment bases, particularly the Bajada Group which is the Riverina's largest employer, the Riverina Institute of TAFE campuses, and the Regional University Study Centre which was established in 2004. Griffith has also experienced strong commercial growth with new shopping centre developments in recent years.[90]

Shepparton, like Griffith, showed an increase in population and employment during the last 15 years. While the size of the agricultural workforce has decreased by 20% since 2001, it has fluctuated at about 2,600 for the last 8 years. However, employment in health care and social assistance has increased significantly (over 30%) during the same period so that it is now notably larger than agricultural employment. There has also been a growth in government investment in public administration and services, and new regional employment opportunities outside of the agricultural sector, such as the Shepparton Bypass project, the road-rail interchange at Mooroopna and additional production jobs at Unilever in Tatura.

The Renmark district has been severely affected by drop in grape prices and this impact has been exacerbated by prolonged drought and the operation of the Small Block Irrigators Exit Grant. Unlike Griffith and Shepparton, Renmark has not experienced a compensating increase in activity in non-agricultural sectors. Instead there has been a contraction in manufacturing and retail trade sectors. This example serves to illustrate the impacts of water reform on highly irrigation-dependent towns that are not yet economically diversified. It is consistent with other research showing that impacts of water recovery are more acute for those communities with greater dependence on irrigated agriculture and less diversified economies.[91]

Adverse effects of water recovery in some smaller communities occurred from water entitlements leaving production, resulting in downsizing or closure of businesses, fewer employment opportunities and reduced revenue streams for supply chain and other supporting services. Adverse effects of water reform may have also occurred as a consequence of the policy to invest in high efficiency, high value enterprises, leading to the rationalisation of farms (e.g. automation, out-sourcing and consolidation) and reduced labour costs.

Nevertheless, impacts of water reforms on employment are relatively small compared to other influences at work. Advances in technology (e.g. round cotton balers, 'Roundup Ready' crops that require less spraying) in the irrigation industry reduced the total demand for seasonal workers reduced by 75% or about 5,000 jobs from 1999 to 2013.[92] Community-level impacts of water recovery were likely to have compounded long-term changes in social and economic structure of some regional communities.

In summary, the Murray-Darling Basin has undergone a significant social and economic transformation in the past decades as a result of a range of economic, social, technological and policy reforms. At a macro level, the gross value of irrigated agricultural production and agricultural production have grown from 2001 to 2011 and have been maintained in the past five years. Agricultural production in the Murray-Darling Basin now contributes around $20 billion to the national economy. Employment in the Basin is also growing, and many sectors are experiencing considerable expansion (e.g. education, health care and social assistance) while others are in decline (e.g. agriculture). However, assessment at sectoral levels reveal divergent trends across the Basin. The decline in agricultural employment in the Basin over the past 15 years is slowing, but is not yet in line with the national trends which show rising agricultural employment in the past 5 years. This is mainly due to declines in employment in dairy farming and growing cotton, grapes, fruit and livestock grain. Trends also varied geographically across the Basin. For example, economic and employment growth has occurred in some regions (e.g. Griffith, Shepparton) but not others (e.g. Renmark, Moree, Deniliquin) as a consequence of a range of drivers. With the right information about these changes and their drivers at different levels, policies can be carefully designed to support those most impacted by reforms to adapt to a future with less water.

Outcome 3: Improving the health of water-dependent ecosystems

The Basin Plan sets out to improve ecological outcomes throughout the Basin as reflected in the sixteen specific outcomes related to river flows and connectivity, native vegetation, waterbirds and fish (Table 2). These objectives are expected to be achieved after 2019 through the recovery and delivery of environmental water and other projects that result in similar ecological improvement. In evaluating the effectiveness of the Basin Plan in achieving these outcomes, there are several considerations:

- **Hydrological outcomes:** Have planned management actions resulted in a hydrological regime predicted to support expected ecological outcomes?
- **Ecological outcomes:** Does environmental watering produce the expected ecological responses?
- **Ecological outcomes at the Basin scale:** Is the overall condition of each of the river valleys and the overall Basin improving?

The Wentworth Group has evaluated publicly available reports to address these questions, focusing on the subset of valleys where environmental water acquired under the Basin Plan was delivered in the three year period from July 2012 to June 2015. We found that there is currently insufficient information in the public domain to enable a proper analysis of progress against the targets in Table 2. Some surveys of broader changes in Basin health are available, however this information is not comprehensive as the Murray-Darling Basin Authority is yet to release its evaluation of the use of environmental water and environmental outcomes (due late 2017/early 2018). The information in the public domain has, however, enabled us to examine whether water recovery has produced demonstrable benefits for river flows and connectivity, native vegetation, waterbirds and fish.

Overall, environmental water available under the Basin Plan has provided benefits for river flows and ecosystems as the Basin transitioned from a wet to dry phase (2011-2015). Many aspects of the Basin's ecosystems receiving additional environmental flows were in better ecological condition than they would have been without the Basin Plan. Environmental watering from 2012 to 2015 played an important role in extending and building on the ecological responses of the previous three wet years, while at the same time slowing the rate of drying and alleviating the associated ecological impacts. However recent surveys of fish, vegetation and waterbirds across large areas of the Basin have indicated no clear improvements yet at the Basin-scale towards the outcomes in Table 2 since the Basin Plan was passed. The 2016 State of the Environment Report reported "deteriorating trends" in ecological processes and key species populations across the Murray-Darling Basin,[50] though no detailed information is available.

The extent to which environmental water will contribute to overall long-term improvements in the Basin's environment will become apparent over coming years as the Basin Plan is implemented fully, monitoring and reporting on targets is completed and made public, and lag effects play out across the Basin. There are major risks to environmental watering which may affect the ability to achieve the Basin Plan objectives (see page 46). Addressing these risks is critical to give the best chance of maximising ecological outcomes, delivering the Basin Plan's ecological objectives and ensuring the highest returns on the public investment in water reform.

ENVIRONMENTAL WATER ALLOCATION AND DELIVERY

In the three years between July 2012 and June 2015, an estimated 8,977 GL of environmental water was delivered to valleys in the Basin over 407 environmental watering events from July 2012 to June 2015 (Table 6). This water is additional to planned environmental water, unregulated flows including dam spills, and environmental water delivered prior to the Basin Plan. Most of this water was delivered in five regions of the southern connected system: South Australian Murray, Goulburn, Victorian Murray, Murrumbidgee and New South Wales Murray (92% of all environmental water delivered in 2013-14 and 86% in 2014-15; Figure 20). The Commonwealth Environmental Water Holder delivered the largest volume of water (4,602 GL, 51%), followed by New South Wales (1,272 GL, 14%) and the Murray-Darling Basin Authority under The Living Murray program (1,059 GL, 12%). Not all environmental water delivered to valleys reached target wetlands for several reasons including constraints in the river system and rules which allow irrigators to legally extract some of this environmental water for private use (see page 56). Unregulated flows and planned environmental water contributed to outcomes in the Basin, however their volume and effects are not reported.

Table 6. Volume of environmental water (GL) delivered by Basin jurisdictions between July 2012 and June 2015.[52] These flows were additional to consumptive and unregulated flows in the river. The same volumes may have been used to water multiple sites.

Year	Volume delivered (GL)							
	CEWH	MDBA	NSW	QLD	VIC	SA	Other	Total
2012-13[1]	1,272	277	670	n/a	364[2]	n/a	n/a	2,583
2013-14[3]	1,663	295	300	15	210	801	232	3,516
2014-15[3]	1,667	488	302	97	198	43	83	2,878
Total	4,602	1,059	1,272	112	772	844	315	8,977

[1] Calculated based on reports by CEWO (2013); MDBA (2013); NSW DPC (2013); VEWH (2013).[33, 93-95] Queensland did not report water delivered. South Australia reported 1,076 GL but it was excluded from this table as the proportion held by South Australia was not known.

[2] Includes some water held by the Commonwealth Environmental Water Holder and under The Living Murray program.

[3] Environmental water use reporting requirement under Schedule 12 Matter 9.3 of the Basin Plan. Reports available at www.mdba.gov.au/publications/mdba-reports/basin-plan-annual-report-2013-2014 and www.mdba.gov.au/publications/mdba-reports/basin-plan-annual-report-2014-15

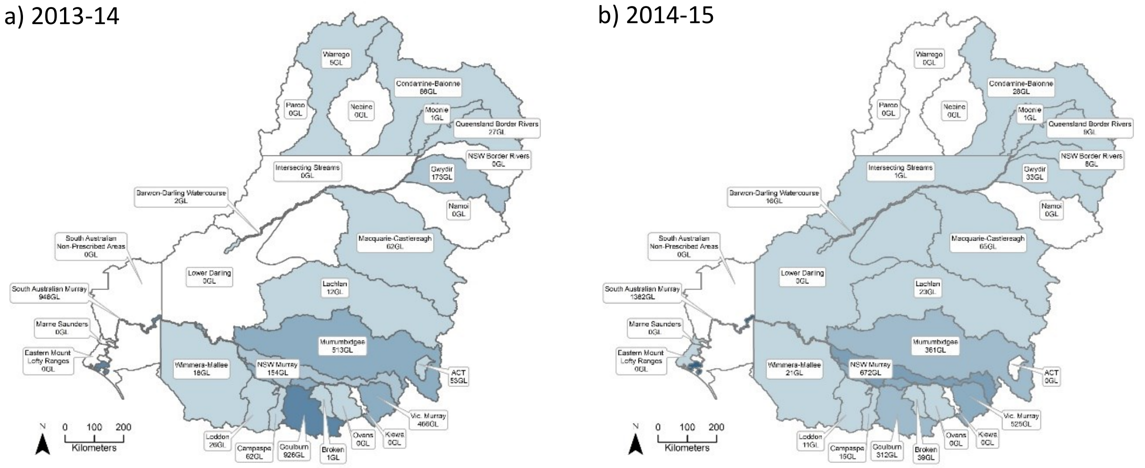

Figure 20. Environmental water delivered by Commonwealth and states in valleys of the Murray-Darling Basin in the (a) 2013-14 and (b) 2014-15 water years, compiled from Schedule 12 Matter 9 reports.[52] Valley-specific data were unavailable for 2012-13.

Dry conditions between 2012 and 2015 were not sufficient to support large scale watering events.[96] The median event size was 0.51GL for environmental flow releases between July 2013 and June 2015.[52] Under these circumstances, environmental watering in 2012-13 was used to build on the ecological responses of the previous three wet years, but as availability declined through 2013-14 and 2014-15, watering was focused on supporting in-channel outcomes and maintaining habitat for freshwater species during drought. Environmental watering actions between 2012 and 2015 were mostly focused on restoring in-channel flows and watering floodplains through infrastructure. Few watering events resulted in overbank flows and natural inundation of floodplains that would have delivered significant environmental benefits.[3]

There was evidence that environmental water holders used strategic approaches to maximise environmental outcomes. For example, for the last six years, environmental water holders have coordinated multi-site environmental watering trials to maximise its effectiveness by re-using return flows in the southern Basin. The trials have tested a range of actions including accounting methods, addition of environmental water to unregulated flows, use of loss factors and coordination of environmental releases with natural flow peaks.[97] Other examples of strategic use of environmental water include actions in which environmental water is used in conjunction with irrigation supply and planned environmental water to achieve a greater variety of water levels than would have been possible with environmental flows alone.

HYDROLOGICAL OUTCOMES

RIVER FLOWS AND CONNECTIVITY

Overall, flood extents were relatively small and localised in the period between 2012 and 2015 compared to the previous wet years, with some recovery in 2016 with the return of wetter conditions. As the Basin transitioned from a wet to dry phase from 2012 to 2015, the area of wetlands surveyed across the Basin declined by two thirds (Figure 21). By 2015, wetland area was similar to levels experienced during the millennium drought. The area of wetlands increased following flooding in 2016, however wetland area remained below the long-term mean.

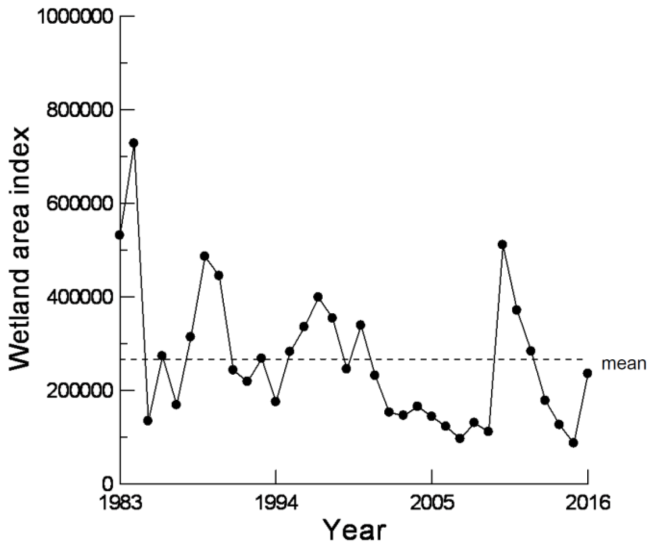

Figure 21. Changes in wetland area (hectares) between 1983 and 2016 across survey bands representing 13.5% of the Murray-Darling Basin (from Porter et al, 2016).[98]

In this period of relatively low flows, environmental water delivery focussed on extending the duration of small- to medium-sized flow events and taper the recession of flow events to better mimic naturally receding flows. For example, environmental flows provided by water managers in the summer of 2013-14 helped to extend the spring unregulated flow and contribute to flows over the South Australian border (Figure 22).

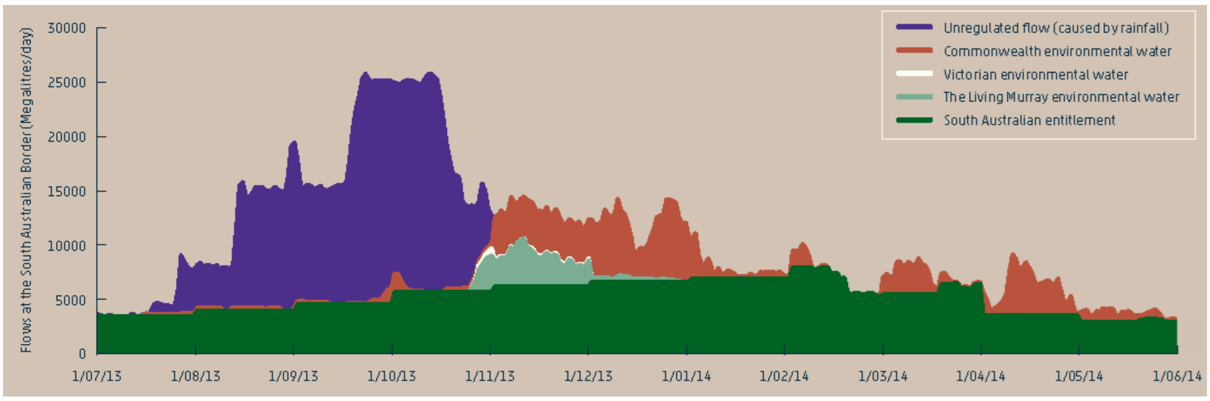

Figure 22. Hydrograph of flows at the South Australian border from July 2013 to June 2014 indicating the contribution of unregulated flow, environmental water held by Basin jurisdictions, and South Australian entitlement flow.[99]

In periods of low flow, environmental water helped to maintain permanent waterholes in channels of the lower Balonne in 2012-13,[94] provide baseflows along channels of the Gunbower forest in 2012-13,[100] break periods of low flow in the Warrego in 2014-15,[101] and extend periods of wetting of channels in the Namoi in 2012-13.[94] Small fresh flows were reinstated with environmental flows in the Barwon-Darling River in 2012-13,[94] the Edward Wakool in 2012-13 and 2013-14,[99, 102] and the Lower Balonne in 2014-15.[103] Freshes improved connectivity between rivers and creeks, mobilised sediment and nutrients, created slackwater habitat for juvenile fish and promoted movement of native fish.[104] The Great Cumbung Swamp in the Lachlan reached maximum capacity in 2012-13 and 2013-14 because of the contribution from environmental watering.[94, 105]

Environmental watering also resulted in overbank flows which naturally inundated floodplain wetlands, mainly in the northern Basin (Table 7). Environmental flows were pumped to isolated wetlands in the mid-Murrumbidgee in 2014-15, with secondary benefits for in-channel habitats.[106] Inundation of important habitat was observed in the Mallowa Creek in the Ramsar-listed Gwydir wetlands (2013-14), where environmental water inundated 1,545 ha of Coolibah-River Cooba-Lignum Association, 337 ha of Coolibah woodlands and around 1,288 ha of cultivated land. Environmental watering in the nationally important Great Cumbung Swamp on the Lachlan floodplain inundated core reed-beds, filled most open water bodies, and spread through river red gum and fringing black box communities.[105]

Table 7. Reported inundation events which benefitted from environmental water between 2012 and 2015.

Region	Area (ha)	Year	Duration & Frequency	Reference
Gingham and Lower Gwydir	6,342	2014-15	4-6 months	CEWO 2015; DOE 2015; EcoLogical and UNE 2015[101, 103, 107]
Mallowa Creek	1,600 2,011	2012-13 2013-14	n/a	CEWO 2013; Southwell et al. 2015[94, 108]
Macquarie Marshes	15,484 9,323	2013-14 2014-15	n/a	OEH 2014b; 2016[105, 109]
Lachlan floodplain	63,000	2013-14	n/a	OEH 2014b[105]
Edward Wakool	n/a	2014-15	n/a	Watts et al. 2015[110]
Lower Murray River, South Australia	~600	2012-13	n/a	CEWO 2013[94]

In a few valleys however, environmental flows were delivered but no significant effects on flow indicators were observed. In the Lower Balonne for example, 22GL of environmental water was delivered in 2013-14, but due to high evaporation losses only a small proportion reached the Narran Lakes.[100] In the Goulburn valley, delivery of environmental water in summer and autumn of 2015 had only a marginal effect on inundation and negligible impact on bank condition, because environmental watering events were small in size, and bank vegetation and other factors exerted a stronger influence over bank condition than flow.[111] The only reported negative flow response to environmental watering was observed in 2014-15 in Yallakool Creek of the Edward Wakool, where there was a reduction in the area of slackwater habitat during watering actions compared to area of available habitat during base flows.[110]

ECOLOGICAL OUTCOMES

Most regions of the Basin receiving environmental water were in better ecological condition than they would have been without environmental watering under the Basin Plan (see Appendix 2). Short-term improvements observed for a range of environmental attributes including vegetation, fish, waterbirds in surveyed valleys (see examples in Box 1). There was also evidence that environmental water alleviated the impacts of drying as the Basin transitioned from a wet period (2010-2012) to a dry period (2013-2015). Very few environmental watering activities reported negative outcomes, and most of these effects were short lived, or not harmful to aquatic biota in the long-term.[112]

Some environmental watering activities did not produce any measurable response, mainly due to insufficient overall flows, lack of flow protection, or factors aside from flow volumes such as water temperature which in some cases may be addressed through complementary measures. For example, there was no waterbird breeding response in the Lachlan River in 2014-15,[103] there was no evidence of anticipated frog spawning at surveyed sites following environmental flow delivery in the Edward-Wakool in 2013-14,[113] and macroinvertebrate biomass did not change in the Goulburn River following environmental flows in 2014-15.[111]

Box 1. Selected outcomes of environmental watering under the Basin Plan between 2012 and 2015.

- **Salt**: Salinity targets were met in three out of five locations in the southern Basin for the 2009 to 2014 reporting period.[62] Nearly 1 million tonnes of salt was exported out of the Basin each year from 2012 to 2015 on average, more than would have been exported without the Basin Plan but less than the Basin Plan outcome of 2 million tonnes.
- **Water quality:** Environmental water prevented dangerously low levels of dissolved oxygen in the lower Broken Creek weirpools in 2012-13.
- **Hydrological connectivity**: Environmental water helped maintain permanent waterholes in the lower Balonne and provided connectivity through to the Narran Lakes and Darling in 2012-13. Environmental water also helped to extend the unregulated flow peak over the South Australian border in late 2013, and contributed to 100% of the flows over the barrages into the Coorong from November 2014 to June 2015.
- **Vegetation**: Aquatic and semi-aquatic plant species abundance and diversity was significantly greater at sites receiving environmental water in the Edward Wakool in 2014-15.
- **Native fish**: Spring freshes in 2014 resulted in the largest golden perch spawning in four years in the Goulburn River, and spawning of the critically endangered silver perch.
- **Waterbirds**: There was a boom in native colonial waterbird breeding following environmental water delivery to Yanga National Park in early 2015, with the breeding of four species including the first breeding of the internationally recognised Eastern great egrets in the Park since 2011. In 2016, there was widespread colonial waterbird breeding in the Lower Lakes, Lachlan River, Kerang wetlands and the Macquarie Marshes.

NATIVE VEGETATION

Native vegetation responded positively to environmental watering, with the establishment of aquatic species and improved condition of flow-tolerant vegetation in those sites that received flooding (see Appendix 2). In areas receiving environmental water, monitoring showed improved condition of floodplain trees, with the canopy showing less dead material and canopy foliage cover generally increasing (e.g. Darling anabranch in 2013-14, Lachlan in 2014-15, Murrumbidgee floodplain in 2012-14, NSW Murray in 2013-14, Gunbower forest in 2014-15, and Koondrook-Perricoota in 2014-15).[101, 105, 109, 114-116] Environmental watering stimulated growth of a number of wetland species in the Lower Gwydir and Gingham wetlands (2012-13), Lachlan (2013-14, 2014-15), Lower Darling (2013-14), Murrumbidgee (2012-13) and Chowilla floodplain (2014-15), as indicated by fresh foliage, mass flowering, seeding, and recruitment.[105, 117] Wetland plant and community diversity increased in response to environmental flows at some sites. For example, increased species diversity was recorded on the Lowbidgee floodplain).[101, 103, 106] and the Loddon where the number of local indigenous plant species at Lake Yando increased from 60 to 97 after environmental watering in 2014-15, including twelve species of rare or threatened plants.[116] Monitoring results were consistent with scientific understanding of the role of environmental water in reducing or suppressing the growth of terrestrial and exotic species in wetlands.

The extent of wetland species increased in valleys in sites where environmental watering occurred in two or more consecutive years. For example, in the Goulburn valley, environmental watering in 2012-13 followed by spring freshes in 2013-14 saw the return of vegetation on the lower Goulburn River to flow-adapted species, with terrestrial species becoming less prevalent.[99, 104] Subsequent delivery of environmental water in 2015 maintained vegetation abundance and diversity in the regions inundated in the previous year.[101, 111] Similarly, vegetation in the Lower Gwydir and Gingham wetlands responded positively to environment watering in 2012-13 and 2013-14 with an increase in area of vegetation communities and increased biomass production, with up to 25 times more biomass in flooded areas compared to non-flooded areas.[117] Similar observations were made in the Edward-Wakool where there was gradual improvement in vegetation at sites that have received environmental water over three years, with greater persistence of submerged aquatic habitat where there was slow recession of flows.[99, 110, 113]

In areas that did not receive environmental watering, monitoring showed aquatic species in decline and transitioning to terrestrial or exotic communities. In the absence of environmental flows in the Lower Lachlan river system, few flow-tolerant species were observed by the end of the 2014-15 water year, and vegetation communities within the floodplains, wetlands and billabongs were dominated by terrestrial species.[115] Significant declines in the cover of aquatic species were observed in the mid-Murrumbidgee wetlands in the absence of environmental water.[118] River red gums in the mid-Murrumbidgee have encroached into previously wetted areas and risk forming dense stands. Successive watering events were not available to promote ecological thinning.[106] Monitoring in the Broken Creek weir pools showed very strong zonation in vegetation from aquatic plants to terrestrial species due to attenuated flow variability which was atypical of a natural flow regime.[104] Sites on the Goulburn River exhibited a more natural, gradual zonation from aquatic plants to terrestrial species where environmental flows have reinstated a more natural flow regime.[99, 104]

WATERBIRDS

Environmental watering has supported outcomes for colonial waterbirds with evidence of localised improvements in abundance and diversity at sites receiving environmental water.[106, 116, 119] Most improvements were related to increases in wetland area and floodplain inundation, providing food and habitat opportunities. Environmental flows were critical for the completion of some colonial waterbird nesting, breeding and fledging events, in conjunction with natural and unregulated flows.[94, 100, 117, 120]

The overall magnitude of site-specific responses was difficult to ascertain as most monitoring reports showed presence/absence of species rather than quantitative measures in relation to a target or expected outcomes. Threatened species were recorded at many sites where environmental watering occurred, but there was no indication of their overall status in relation to obligations under international migratory bird agreements (e.g. JAMBA, CAMBA and ROKAMBA).

NATIVE FISH

Native fish responded positively to environmental flows delivered between 2012 and 2015, with outcomes reported for spawning and fish movement. There was evidence to suggest that environmental flows have enhanced juvenile recruitment success of some species including Australian smelt and Murray cod in the Murrumbidgee[94, 117, 120] and golden perch in the South Australian Murray.[121] Spawning of adult golden perch in the Goulburn River[99, 104] and bony bream and spangled perch in the Gwydir valley were directly attributed to environmental flows in 2013-14.[99, 105, 108] However there is insufficient evidence to date suggesting that spawning events resulting from environmental flows have translated into recruitment of juveniles into the local population. There was no conclusive evidence that environmental water stimulated carp breeding or movement in the Basin. Between 2012 and 2015, the Macquarie Marshes was the only site where carp recruitment was reported as prolific following environmental watering.[103, 109, 122]

CONDITION OF THE LOWER LAKES, COORONG AND MURRAY MOUTH

An overall objective for the Basin Plan is to provide a “healthy and working Murray-Darling Basin that includes…healthy and resilient ecosystems with rivers and creeks regularly connected to their floodplains and, ultimately, the ocean” (s5.02 (2) (a)). The Basin Plan also contains a series of objectives and outcomes related to the Lower Lakes, Coorong and Murray mouth:

1. *Objectives for water levels of the Lower Lakes (s8.06 (3) (e))*: The levels of the Lower Lakes are managed to ensure sufficient discharge to the Coorong and Murray mouth and help prevent river bank collapse and acidification of wetlands below Lock 1, and to avoid acidification and allow connection between Lakes Alexandrina and Albert, by (i) maintaining levels above 0.4 metres Australian Height Datum for 95% of the time, as far as practicable; and (ii) maintaining levels above 0.0 metres Australian Height Datum all of the time.

2. *Objectives for salinity levels and salt export (s9.09 (3))*: Average discharge of 2 million tonnes of salt from the River Murray System into the Southern Ocean likely for each water accounting period; Requirements of salinity levels to be achieved 95% of the time: Lower Lakes at Milang 1000 EC (uS/cm).

3. *Objectives for barrage flows (s6.07 (c) and BWS[27])*: Barrage flows are greater than 2000 GL per year on a three year rolling average basis with a minimum of 650 GL in any year, to be achieved for 95% of years; and barrage flows are greater than 600 GL over any two year period, to be achieved for 100% of the time.

4. *Objectives for openness of the Murray Mouth* (s8.06 (3) (c-d)): The Murray mouth remains open at frequencies, for durations, and with passing flows, sufficient to enable the conveyance of salt, nutrients and sediment from the Murray-Darling Basin to the ocean; and the Murray mouth remains open at frequencies, and for durations, sufficient to ensure that the tidal exchanges maintain the Coorong's water quality (in particular salinity levels) within the tolerance of the Coorong ecosystem's resilience.

5. *Ramsar objectives* (s8.05 (2) (a)): The Basin Plan also contains an objective to ensure that declared Ramsar wetlands (including the Lower Lakes and the Coorong, that depend on Basin water resources maintain their ecological character.

1. Lake levels

The condition of the Lower Lakes has improved as a result of river flows following the millennium drought, at which time lake levels dropped below sea level. Water levels in the Lower Lakes have returned to levels prior to the millennium drought (Figure 23). Since 2010, Lake Alexandrina water levels have oscillated annually between 0.4m and 0.9m AHD, reflecting inflows, outflows and evaporation losses. Water level targets in Lake Alexandrina have also been achieved since the Basin Plan has been in place (s8.06 (e) of the Basin Plan). Environmental water contributed to achieving lake level targets, particularly in the 12 month period from June 2014 to July 2015 when environmental water was the main source of inflow into Lake Alexandrina.[3]

2. Salinity and water quality

Water quality in the Lower Lakes has also improved since the millennium drought with the increase in freshwater inflows including environmental water. Salinity levels in Lake Alexandrina at Milang have remained below 1,000EC (Figure 23), although they came close to this threshold in the dry winter of 2016. Salinity targets for Milang,[123] measured as long-term averages, have not been achieved because of the influence of the millennium drought on average calculations. Modelling suggests that the Commonwealth environmental water delivered between 2014 and 2015 had no effect on in-channel salinity levels upstream but these additional flows increased salt exports from the Murray River Channel, Lower Lakes and Coorong, contributing 21% and 64% of the total modelled export from the Lower Murray River Channel and Lower Lakes, respectively.[124] Modelling suggests that Commonwealth environmental water greatly reduced the net import of salt to the Coorong during 2014–15 due to increased outflows (from 3.2 × 106 tonnes down to 1.6 × 105 tonnes).[125] Salt export targets are reported on page 22.

However, additional environmental flows were not sufficient to enable surface and groundwater quality in large parts of the region to fully recover from the drought, and in some areas water quality remains poor. In Lake Albert, salinity levels had not returned to pre-drought levels by February 2016.[126] Monitoring by the South Australian Environmental Protection Agency across the region from 2011 to 2016 found ongoing low levels of acidity at some previously acidified locations, and acidic shallow groundwater at multiple sites.[126] The Environmental Protection Agency concluded that water quality, soil, ecosystems and infrastructure may not fully recover from the impacts of poor water quality that followed the severe drought.

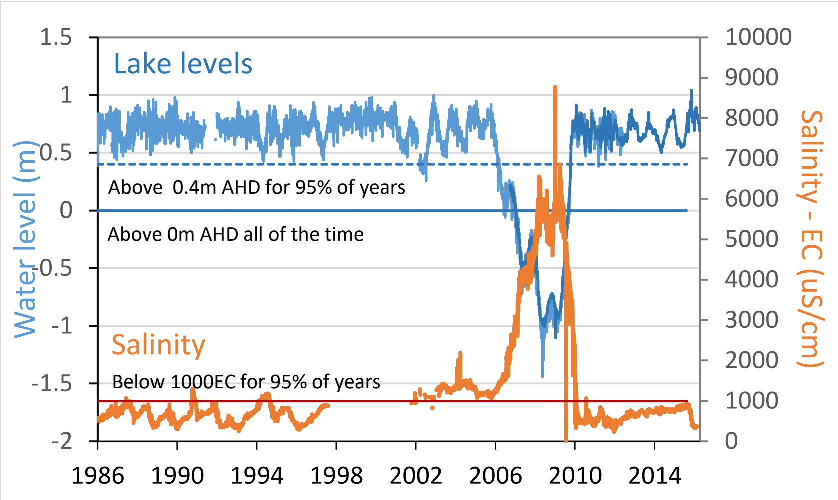

Figure 23. Daily water levels (blue) and salinity levels (red) for Lake Alexandrina from 1986 to 2015 measured at Milang.[127] Basin Plan targets are shown for water levels (s8.06 (e)) and salinity (s9.14 (5) (c)).

3. Barrage flows

Barrage flows for the 2012–15 reporting period (2,680 GL/yr) were within the 2,000 GL/yr minimum target in the Basin-wide environmental watering strategy.[128,3] However there was considerable variation between years. Barrage flows over spring 2016 were low even though lake levels were above full supply level (0.75m AHD; Figure 24). A report commissioned by the Commonwealth Environmental Water Holder concerning the current management of lake levels stated that South Australia "appears to prioritise high lake water levels over maintenance of flows to the Coorong and Murray mouth".[3] With the limited environmental water available, retaining high water levels in the Lower Lakes at the expense of barrage flows compromises the connection of the river to the sea, and may put at risk the Australian Government's international obligations to protect the Coorong under the Ramsar Convention. This is discussed on page 63 in more detail.

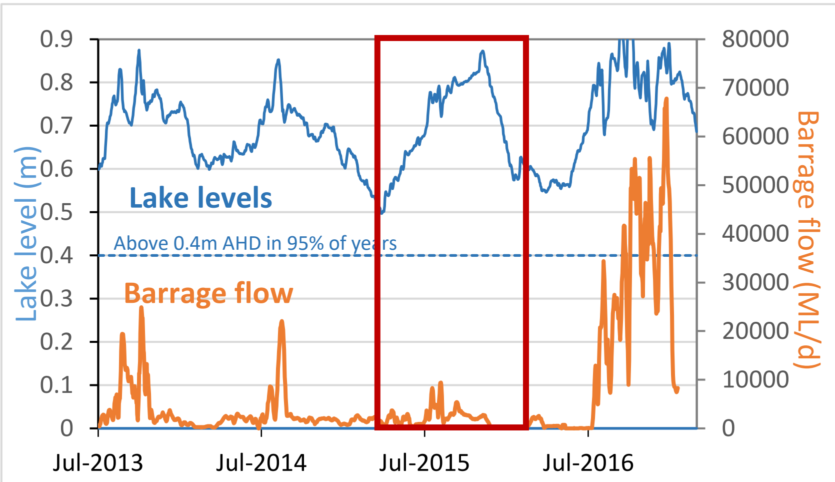

Figure 24. Water levels at Milang in Lake Alexandrina and barrage flow for the period 2013 to 2016. Red rectangle indicates the period where high water levels were prioritised over barrage flows to the Coorong and Murray mouth. Water level data was from MDBA's River Murray Data portal and barrage flow supplied by South Australian Department of Environment and Natural Resources.

4. An open Murray mouth

A Basin Plan objective is for the Murray mouth to "remain open at frequencies, for durations, and with passing flows, sufficient to enable the conveyance of salt, excess nutrients and sediment from the Murray-Darling Basin to the ocean" (s8.06 (c)). A further outcome to be pursued with a Commonwealth program to deliver 450 GL is the "mouth of the River Murray is open without the need for dredging in at least 95% of years" (Sch 5 (2) (c)). This target for the Murray mouth is far from being met. To date, it is only during periods of unregulated flow (i.e. floods) that the Murray mouth has been scoured open by river flows (e.g. 2010, 2016; Figure 25). At other times, dredges were required to maintain an open Murray mouth, given the power of the sea in bringing sand into the mouth (e.g. 2003 to 2006 and 2014 to 2015) at a cost of about $6 - 7 million per year.[129] Even with one dredge in operation, there was a net sand accumulation into the mouth due to very low barrage flows (e.g. 2006 to 2010). Since the construction of the barrages in the 1930s, large quantities of sand have accumulated between the mouth and the barrages, further restricting egress of river water through the mouth when being released over the barrages. This sand accumulation has formed a continually growing flood tidal delta that includes Bird Island.[130] A report commissioned by the South Australian Government in 2017 showed the rate of sediment inflow from the sea is around 2,250m^3 per day based on surveys between June 2015 and July 2016.[131] During winter 2016, a larger than usual number of severe storms contributed to higher ocean levels, Murray mouth sedimentation and shoal development.[131] Data provided on volumes dredged for 2015-16 indicate the necessity for two dredges to sustain an open mouth. Given continued onshore sand transport to the mouth, it is unlikely that targets for an open Murray mouth can be met in the future without dredging.

Freshwater flow through the barrages as well as an open Murray mouth is necessary to sustain the ecological health of the tidally-flushed north Coorong and the more saline south Coorong. A Basin Plan objective for water-dependent ecosystems is "the Murray Mouth remains open at frequencies, and for durations, sufficient to ensure that the tidal exchanges maintain the Coorong's water quality (in particular salinity levels) within the tolerance of the Coorong ecosystem's resilience" (s8.06 (d)). Higher River Murray flows and water releases through the barrages and into the Coorong in late 2010 resulted in decreasing salinity, decreasing total nitrogen (mg/L) and decreasing total phosphorus, while chlorophyll *a* and turbidity increased from 2011 to 2016.[126]

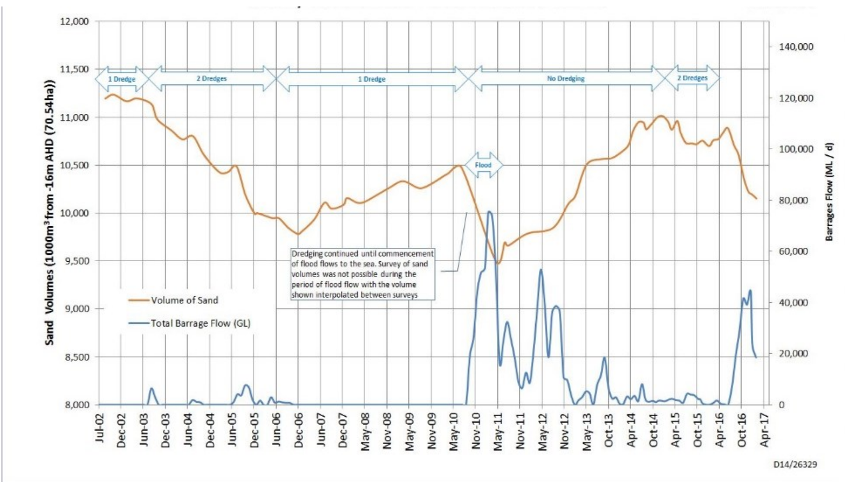

Figure 25. Barrage flow, sand volumes and dredging of the Murray mouth between 2002 and 2017. Supplied by South Australian Department of Environment and Natural Resources.

5. The Coorong Ramsar site

Recent work by Paton and colleagues have highlighted complex relationships between Coorong water levels, salinity, aquatic vegetation and waterbirds.[132, 133] Since the return of freshwater flows to the Coorong, the recovery of the seagrass *Ruppia tuberosa* in the South Lagoon has been slow. *R. tuberosa* is a source of food and habitat for macroinvertebrates and fish, and provides food for migratory waterbirds. Extensive beds of *R. tuberosa* that had gradually established in the North Lagoon between 2006 and 2010 were quickly lost following the return of freshwater flows, probably due to interference from filamentous green algae. There has been limited improvement since. Although flows returned to the region in spring 2010, flows diminished dramatically during each spring of the next five years (2011-2015) resulting in water levels once again falling at critical times for *R. tuberosa* production. It is clear from trends in *R. tuberosa* and other condition indicators, that the availability and management of water is not yet sufficient to meet the objectives of the Basin Plan for the Coorong, Lower Lakes and Murray mouth, nor is it adequate to maintain the ecological character of the Ramsar wetlands. The South Australian and Commonwealth Governments need to undertake a medium-term process of scientific assessment and stakeholder consultation to identify more realistic long-term management options for the Coorong.

ECOLOGICAL OUTCOMES AT THE BASIN SCALE

Since 2012-13, many environmental outcomes have been observed at the specific sites where environmental water was directed, however there are many more sites across the Basin which have not received sufficient environmental flow and remain in a poor and degrading condition (e.g. see Appendix 2). Improvements in the condition of the Basin across large scales have not yet been assessed and reported. We are also yet to observe longer lasting improvements in the Basin's environment because, like watering a garden after a drought, it will take consecutive watering events for degraded ecosystems to respond given the lag effects and the trajectory of declining health in past decades. Even when the Basin Plan is implemented in full with constraints relaxed, only 66% of the 112 target environmental water requirements set by the Murray-Darling Basin Authority in 2012 are expected to be achieved.[156]

We do not have Basin-wide monitoring in place that measures condition of river systems and enables detection of ecological changes even when they become apparent. No measures of Basin-wide health have been produced since the Sustainable Rivers Audit was discontinued. The Sustainable River Audit was a Basin-wide assessment of river health for the 23 valleys of the Basin for key indicators — vegetation, physical form, macroinvertebrates, fish and hydrology. It was an initiative of Basin governments, coordinated by the Murray–Darling Basin Authority, and overseen by a panel of independent ecologists. Two audits were undertaken for the periods 2004 to 2007 and 2008 to 2010. In 2012, states cut funding for the joint management of the Murray-Darling Basin system and as a consequence, Basin governments decided to cease the audit.[134] Without the ability to track the condition of the Basin it is not possible to understand the ecological changes at a valley and Basin scale.

NATIVE VEGETATION

The stand condition of woody vegetation (river red gum and black box) was monitored at seven icon sites in the Southern Basin totalling 134,000 ha in area.[43] This analysis included areas that have not received environmental water or natural flooding since at least 2009. Between 2009 and 2015, there was an 11% decline in the area of red gum and black box stands classified as good condition, and a 26% increase in the area that was classified as severely degraded (Figure 26).[135] Black box stands were generally classified in poorer condition than red gum stands, because black box stands are situated in the upper floodplains which are less frequently flooded.[135] Due to the dry conditions there was very little environmental water available in The Living Murray portfolio until 2010-11. The Living Murray works only started to become operational at different icon sites between 2013 and 2016. Data on recruitment, understorey and other aspects of vegetation condition were not included in the assessment of stand condition.

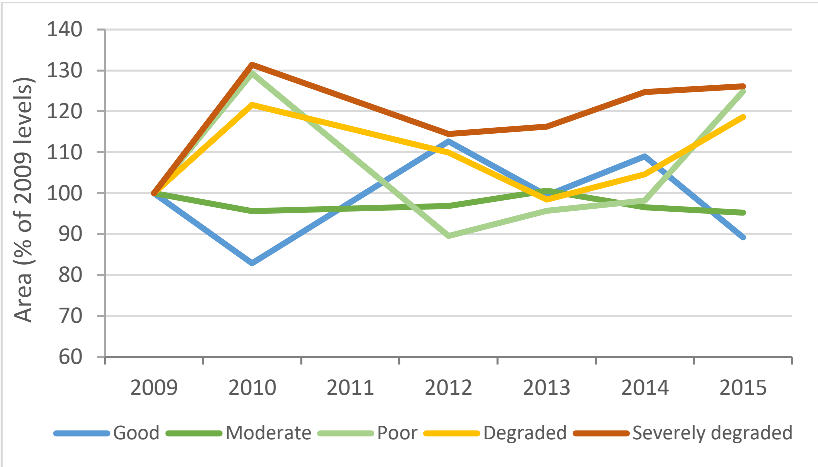

Figure 26. Change in area of floodplain forests and woodlands of different condition across seven Living Murray sites (total of 134,200 ha) relative to 2009 areas. (Source: Compiled from MDBA's stand condition reports; error not quantified).[43]

WATERBIRDS

Colonial waterbird abundance measured using the Eastern Australian Waterbird Survey for the sample area (13.5% of the Basin) peaked at the beginning of the 33 monitoring period at about 700,000 individuals (1984), then declined through the Millennium drought to a record low of less than 50,000 individuals (2009; Figure 27).[98] Drought-breaking rains in 2010 and 2011 led to a small recovery in waterbird abundance, reaching about 350,000 individuals (2012). Further, aerial waterbird surveys across the major wetlands of the Murray-Darling Basin showed low populations of waterbirds after 2012, following a small peak in population during the wet period from 2010 to 2012 (Figure 27).[98]

Between 2012 and 2015, declines were observed in total waterbird abundance, wetland area, breeding abundance and breeding species richness,[98] interrupted by a peak related to the wet period from 2010 to 2012. Colonial waterbird abundance has not exceeded 100,000 individuals in any year since the Basin Plan was implemented.[98] Declines were related to reduced frequency and magnitude of flows and inundation extent due to changes in climate and impacts of river regulation, given large-scale colonial waterbird breeding generally requires large areas of wetland (>20,000 ha) to be inundated.[118]

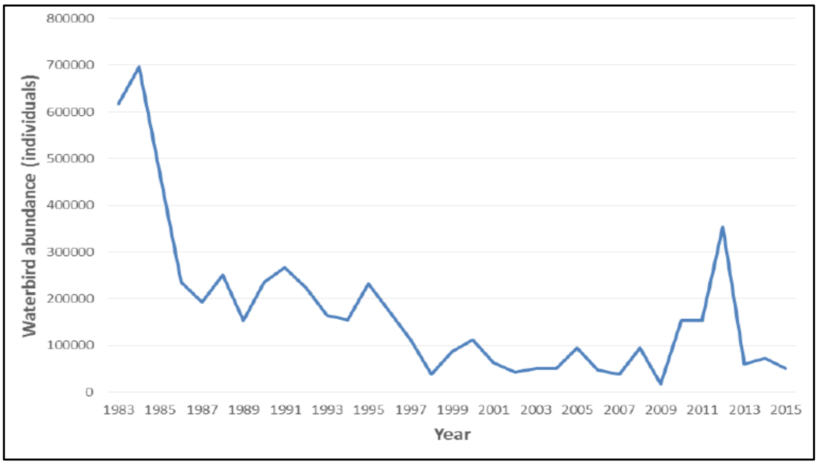

Figure 27. Waterbird abundance across the Murray–Darling Basin 1983–2015 (as estimated during aerial waterbird surveys).[98]

The ten most important wetlands for waterbird breeding in the past 33 years have been Lowbidgee, Cuttaburra Channels, Menindee Lakes, Macquarie Marshes, Paroo overflow, Darling River, Corop Wetlands and the Coorong, Lower Lakes and Murray mouth, Fivebough Swamp and Coolmunda Dam. These wetlands, together with seven additional sites, represented 80% of total abundances of all 52 waterbird species over the 33 year period.[136] Different wetlands were important for waterbirds in dry years compared to wet years. In dry years, waterbirds preferred 12 river and lake habitats for refugia, while in wet years waterbirds preferred 8 lake and wetland habitats as breeding grounds.

NATIVE FISH

The abundance and distribution of native fish has declined in the past 50 years (Figure 28).[137] In the southern Basin, native fish populations in the Murray River have declined to about 10% of the pre-European level over the last 100 years.[121] In the northern Basin, fish communities in most valleys are in extremely poor to poor condition, with the exception of the Border Rivers (moderate), Condamine (moderate) and Paroo (good; Figure 29).[138] Low condition scores for the Lower Lachlan were attributed to a number of native species predicted to have historically occurred within the area that were absent (50% of species absent) and because recruitment within the population was observed to be very low.[115]

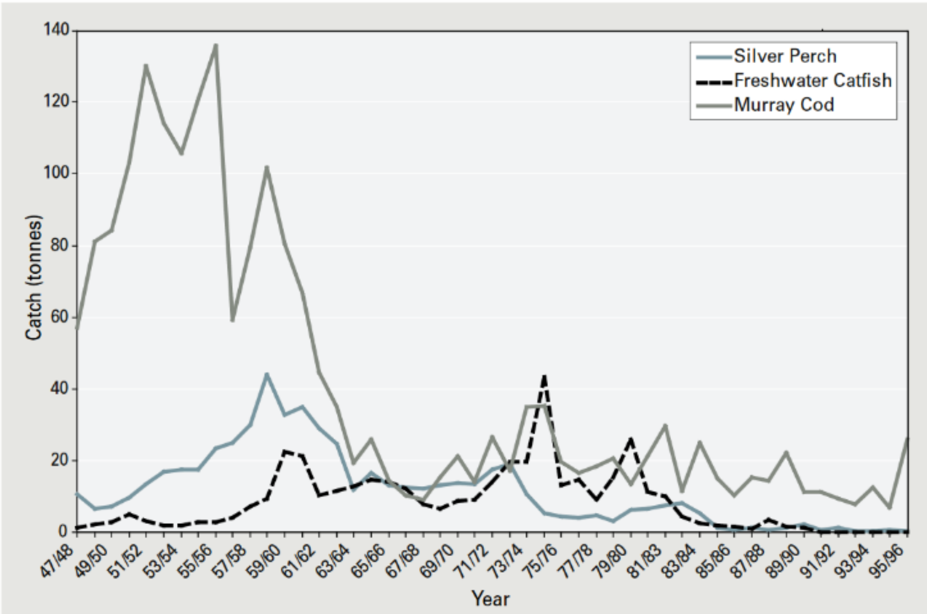

Figure 28. Decline in commercial catches of Murray cod, Freshwater catfish and Silver perch in NSW between 1947 and 1996 (Source: Reid et al. (1997) in Lintermans (2009)).[139]

Despite the localised benefits of environmental water, fish communities in most valleys in the Murray-Darling Basin of New South Wales, particularly in the southern Basin, remained in poor to extremely poor condition in 2015 (Figure 29).[138] Results also showed the condition of fish communities changed within valleys, for example in the Macquarie River, where fish condition declined along a downstream gradient from ‘poor’ below Burrendong Dam to ‘extremely poor’ downstream of the Macquarie Marshes .[122] There was a small improvement in trend of the native fish communities in some valleys (e.g. from ‘very poor’ to ‘poor’ in the Edward-Wakool).[113]

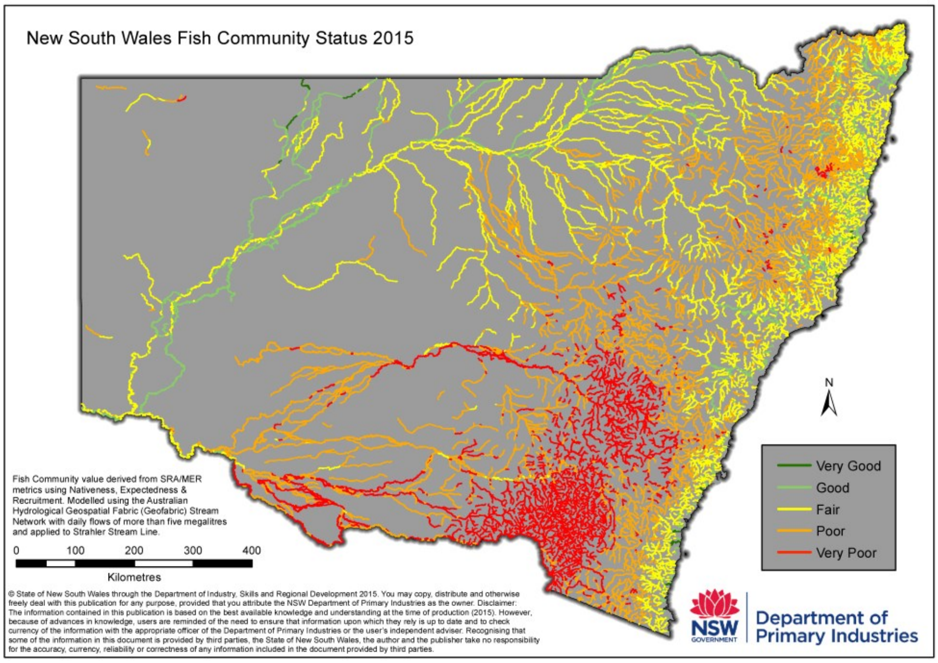

Figure 29. Fish community status in New South Wales.[138]

RAMSAR OBLIGATIONS

The mandate for the Water Act 2007 and the Basin Plan is based on Australia's international environmental obligations. Under the Ramsar Convention on Wetlands, Australia has committed to protecting the ecological character of sixteen internationally recognised wetlands in the Murray-Darling Basin. Table 8 shows the expected improvement in flow indicators at Ramsar sites as a result of the Basin Plan. For example in the Barmah-Millewa forest Ramsar site, the proportion of years with a successful event of 12,500 ML/d for 70 days from June to November will be restored from 57% to 95% of its natural state.

The Australian Government's 2015 national report on the implementation of the Ramsar Convention reported that the ecological character had improved for three wetlands (Gwydir wetlands, Coorong and Lower Lakes and Banrock Station), stayed the same for ten wetlands, and declined for one site (Riverland) since the last triennium report (Table 9).[42] Deterioration in the ecological character status of the Riverland region was attributed to changed hydrologic regime and changing climate.[58]

While many of these wetlands may have marginally improved since the last report, e.g. Gwydir wetlands, they remain in a degraded condition that does not meet the ecological character description for which they were listed under the treaty. Vegetation condition assessments by the Murray-Darling Basin Authority in 2015 show that less than a third of the area of red gum and black box forests across all surveyed sites was in good condition, and the area of forests in degraded or severely degraded has increased since 2009 (Figure 26).[43] Red gum or black box forests were identified as critical components of ecological character, or support critical components of ecological character, of the Ramsar sites surveyed.[140-144] This decline in line with predictions that eight of the ten Ramsar sites assessed in the modelling underpinning the Basin Plan (2,800 GL water recovery scenario) are likely to decline beyond the "limits of acceptable change" mandated under the Ramsar Convention in the long-term.[145]

Under a median climate scenario, the period between flood events at the Riverland Ramsar site is expected to double and volumes are expected to be reduced to 23% of natural conditions, with adverse consequences for floodplain vegetation.[146] Similarly, there is evidence that NSW Central Murray State Forest "is on a trajectory of decline and it is thought that hydrological conditions at the time of listing were insufficient to maintain the ecological character of the site".[141] Additional pressures including drought and hypersalinisation have resulted in adverse changes to the ecological character of Ramsar wetlands as reported in past assessments, including the Coorong and Lower Lakes.[44-46].

Table 8. Achievement of flow indicators for Ramsar sites in the Murray-Darling Basin, showing the proportion of years with a successful event relative to the natural (without development, WOD) scenario.[147]

Ramsar site	Proportion of years with successful event (as a % of WOD)		
	Without dev.	Pre-Basin Plan	Basin Plan (3,200 GL)
Fivebough and Tuckerbil Swamps	100%	N/A	
Gwydir Wetlands			
150 ML/Day for 45 days from Oct - Jan	100%	213%	232%
1000 ML/Day for 2 days from Oct - Jan	100%	96%	96%
45 GL during October & March	100%	104%	118%
60 GL during October & March	100%	111%	116%
80 GL during October & March	100%	92%	100%
150 GL during October & March	100%	69%	72%
250 GL during October & March	100%	79%	86%
Narran Lakes	100%	N/A	N/A
NSW Central Murray State Forests	100%	N/A	N/A
Paroo River Wetlands	100%	N/A	N/A
Macquarie Marshes			
1.5 year ARI at Marebone Break	100%	85%	86%
2.5 year ARI at Marebone Break	100%	93%	93%
5 year ARI at Marebone Break	100%	97%	97%
Barmah-Millewa Forest			
12,500 ML/d for 70 days from Jun - Nov	100%	57%	95%
16,000 ML/d for 98 days from Jun - Nov	100%	45%	92%
25,000 ML/d for 42 days from Jun - Nov	100%	45%	71%
35,000 ML/d for 30 days from Jun - May	100%	45%	58%
50,000 ML/d for 21 days from Jun - May	100%	46%	46%
60,000 ML/d for 14 days from Jun - May	100%	42%	33%
15,000 ML/d for 150 days from Jun - Dec	100%	25%	82%
Gunbower-Koondrook-Perricoota Forest			
16,000 ML/d for 90 days from Jun - Nov	100%	36%	83%
20,000 ML/d for 60 days from Jun - Nov	100%	39%	70%
30,000 ML/d for 60 days from Jun - May	100%	42%	65%
40,000 ML/d for 60 days from Jun - May	100%	28%	62%
20,000 ML/d for 150 days from Jun - Dec	100%	16%	67%
Hattah Lakes			
40,000 ML/d for 60 days from Jun - Dec	100%	45%	75%
50,000 ML/d for 60 days from Jun - Dec	100%	40%	70%
70,000 ML/d for 42 days from Jun - Dec	100%	29%	55%
85,000 ML/d for 30 days anytime	100%	30%	42%
120,000 ML/d for 14 days anytime	100%	35%	35%
150,000 ML/Day for 7 consecutive days anytime	100%	29%	35%
Kerang Wetlands	100%	N/A	N/A
Lake Albacutya	100%	N/A	N/A
Currawinya Lakes	100%	N/A	N/A
Coorong and Lakes Alexandrina and Albert	100%	N/A	N/A
Banrock Station Wetland Complex	100%	N/A	N/A
Riverland-Chowilla Floodplain	100%		
20,000 ML/d for 60 days from Aug - Dec	100%	48%	84%
40,000 ML/d for 30 days from Jun - Dec	100%	46%	76%
40,000 ML/d for 90 days from Jun - Dec	100%	38%	67%
60,000 ML/d for 60 days from Jun - Dec	100%	29%	66%
80,000 ML/d for 30 days anytime	100%	29%	41%
100,000 ML/d for 21 days anytime	100%	32%	37%
125,000 ML/d for 7 days anytime	100%	24%	24%

*Based on 150GL water recovery scenario in the Condamine-Balonne valley.

Table 9. Sixteen Ramsar wetlands in the Murray-Darling Basin, their change in ecological character as reported by the Australian Government to the Ramsar Convention's 12th Conference of Parties in 2015 and the Murray-Darling Basin Authority's 2015 assessment of condition of red gums and black box forests.[42, 148]

Wetland	Australian Government assessment 2015[42]	MDBA vegetation condition assessment 2015[148]
Fivebough and Tuckerbil Swamps (NSW)	No change	n/a
Gwydir Wetlands (NSW)	Status improved	n/a
Narran Lakes (NSW)	No change	n/a
NSW Central Murray State Forests (NSW)	No change	Millewa: Good (18%), Moderate (71%), Poor (9%), Degraded (1%), Severely degraded (1%) Koondrook: Good (5%), Moderate (66%), Poor (27%), Degraded (2%), Severely degraded (<1%)
Paroo River Wetlands (NSW)	No change	n/a
Macquarie Marshes (NSW)	No change	n/a
Barmah Forest (Vic)	No change*	Good (32%), Moderate (64%), Poor (4%), Degraded (<1%), Severely degraded (<1%)
Gunbower Forest (Vic)	No change*	Good (19%), Moderate (63%), Poor (18%), Degraded (<1%), Severely degraded (<1%)
Hattah-Kulkyne Lakes (Vic)	No change*	Hattah: Good (2%), Moderate (29%), Poor (23%), Degraded (42%), Severely degraded (4%)
Kerang Wetlands (Vic)	No change**	n/a
Lake Albacutya (Vic)	No change	n/a
Currawinya Lakes (Qld)	No change	n/a
Coorong and Lakes Alexandrina and Albert (SA)	Status improved	n/a
Banrock Station Wetland Complex (SA)	Status improved	n/a
Riverland (SA)	Status deteriorated***	Chowilla: Good (6%), Moderate (24%), Poor (8%), Degraded (44%), Severely degraded (18%)
Ginni Flats Wetland Complex (ACT)	No change	n/a

*A preliminary assessment of potential change in ecological character is underway, due to one or more Limits of Acceptable Change (LACs) being exceeded as of June 2011. There is no evidence that the site as a whole has undergone further adverse change in ecological character since then. In fact, in the last triennium conditions at the site have improved due to the ending of a long period of drought in 1997- 2009.

** Some LACs have been exceeded for this site, however a preliminary assessment is not proposed at this time. There is no evidence that the site as a whole (comprised of 23 separate wetlands) has undergone a change in ecological character since the last triennium. In fact, in the last triennium conditions at the site have improved due to the ending of a long period of drought in 1997-2009.

***A formal assessment of change of ecological character is in development.

Actions needed to deliver the Basin Plan ‘on time and in full’

The National Water Initiative, the Water Act 2007 and the Basin Plan are nationally significant reforms aimed at bringing Australia’s most productive river basin back into a more sustainable balance. Our review of water reform in the Murray-Darling Basin shows that progress has been made in some aspects of water reform, however there remain many major risks to the delivery of the Basin Plan.

We have identified five key risks to delivering a Basin Plan ‘on time and in full’:

1. Erosion of public trust;
2. Failure to reach the target of 3,200 GL or equivalent outcomes;
3. Risk that environmental flows are being undermined and fail to reach their target location;
4. Inadequate support for communities most affected by water reform; and
5. Managing water in a changing climate.

To address these risks, we have identified five actions needed to deliver the Basin Plan:

1. Rebuild trust with greater transparency; and
2. Guarantee recovery of the full 3,200 GL or genuinely equivalent outcomes;
3. Ensure that water recovered achieves measurable improvements to the river system;
4. A regional development package that puts communities at the centre of reform;
5. Prepare for the prospect of a future with less water.

In this section, we describe the nature of these risks and the actions needed to deliver the Basin Plan in full.

1. Rebuild trust with greater transparency

The 2004 National Water Initiative was almost universally supported, and the Basin Plan was a bipartisan agreement, yet how governments have gone about these reforms has resulted in conflicts among communities and this has contributed to an overwhelming erosion of public trust in government.

The first sign that trust had been lost was in the development of the Basin Plan itself, which put bureaucrats in charge rather than allowing communities to be at the front and centre of the solution. We saw a centralist, top down program driven by government agencies, where one arm of government produced a plan, while another arm spent billions of dollars without any genuine consultation with the communities affected. Release of ‘The Guide to the proposed Basin Plan’ in October 2010 and the disaffection from communities that followed, reflected the breakdown of public trust.

The second sign of the erosion of trust was when the Murray-Darling Basin Authority ignored the best available science for delivering a healthy, working Murray-Darling Basin and instead “manipulate[d] science in an attempt to engineer a pre-determined political outcome”.[24] In Senate hearings in November 2012, the Wentworth Group stated “there has been no scientific evidence produced by the Authority to suggest that 2,750 or 3,200 would achieve the objectives of the Water Act,”[149] and “the Australian community in that scenario would have been misled by the parliament”.[150]

Institutional changes since the Basin Plan was enacted have reduced national oversight over water reforms with little accountability of governments to their commitments. The Murray-Darling Basin Ministerial Council abandoned the Sustainable Rivers Audit in 2012 (a program to measure the condition of the 23 valleys in the Basin) when states withdrew funding. In 2013, the Council of Australian Governments Standing Committee on Environment and Water was discontinued, and in 2014, the independent water reform review body (the National Water Commission) was abolished.

In 2017, revelations of possible water theft and meter tampering by ABC Four Corners have exposed the inadequacy of New South Wales Government’s monitoring and compliance regimes. An investigation by the

New South Wales Ombudsman in November 2017 stated that “these failures potentially affected the integrity and reputation … and undermined public confidence in the water regulation system”.[151]

Water reform is essential to restore over-allocated systems, and successful water reform must be built on cooperation and transparency so the public can trust the reforms are both fair and effective. To rebuild trust, four actions are required to create greater transparency and restore community confidence in governments to progress water reform:

1. Improve metering and compliance;
2. Improve accountability;
3. Reinstate a basin-wide river health monitoring program; and
4. Strengthen regulatory capacity.

1.1 Improving metering and compliance

Metering of all water extractions is fundamental for equitable and sustainable management of water in the Murray-Darling Basin. It is also a goal of the 2004 National Water Initiative. Across the Basin, 30% of the total surface water extraction and 10% of extractions from watercourses are unmetered (Figure 30). In 2017, with all the technology, the significant value of water, and the $500 million investment in water accounting, it is inconceivable that we do not know how much water is being extracted from surface and groundwater systems for consumptive use.

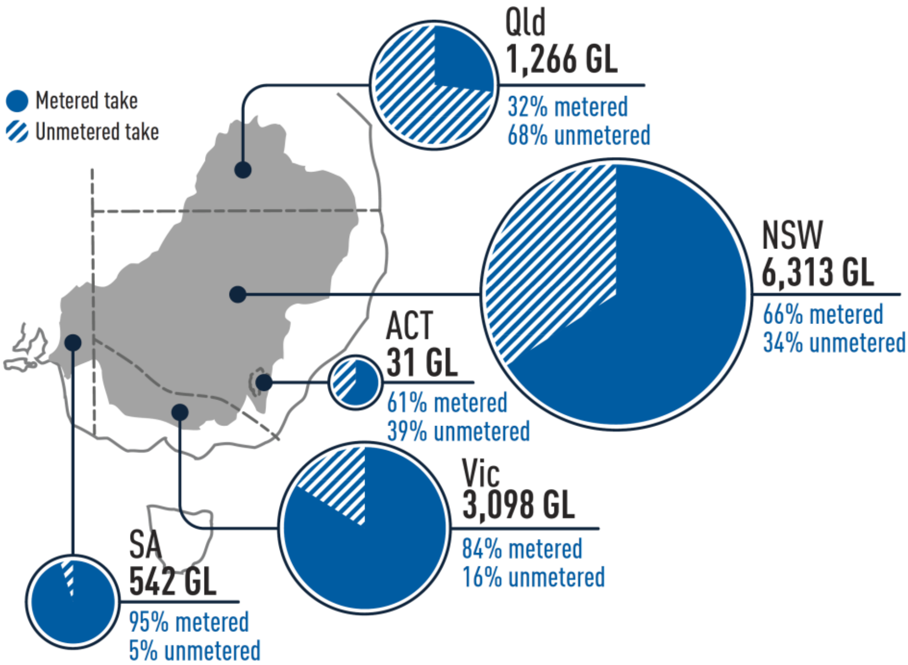

Figure 30. Average annual take (all forms) in the Northern and Southern Basins from 2012-13 to 2015-16. Source: MDBA 2017.[152]

Inadequate metering, enforcement and compliance regimes have been reported at least since the National Water Commission’s 2009 biennial assessment. While some improvements have been made since 2009, the Commission’s 2014 report identified progress was lacking in key areas: “the generation of groundwater data is still significantly underfunded and poorly appreciated and environmental water accounting remains incomplete. In addition, metering and measuring provides the basis for water use accountability and allows water markets to function, but the National Framework for Non-Urban Metering has not been implemented.”[153]

In October 2016, the statutory Northern Basin Advisory Committee of community representatives warned the Murray-Darling Basin Authority of the ineffective compliance regimes in the northern Basin, where “current compliance regimes are poorly resourced and ineffective […] the potential to derail the Basin Plan is glaringly obvious."[154]

Following allegations of water theft raised on the ABC's Four Corners program in July 2017, an independent investigation into New South Wales water management and compliance by Mr Ken Matthews (2017) found that "water-related compliance and enforcement arrangements in NSW have been ineffectual and require significant and urgent improvement".[155] Specifically:

- "The overall standard of NSW compliance and enforcement work has been poor.
- Arrangements for metering, monitoring and measurement of water extractions, especially in the Barwon–Darling river system, are not at the standard required for sound water management and expected by the community.
- Certain individual cases of alleged non-compliance have remained unresolved for far too long.
- There is little transparency to members of the public of water regulation arrangements in NSW, including the compliance and enforcement arrangements which should underpin public confidence."[155]

The interim Matthews report to the New South Wales government proposed a range of Basin-wide initiatives to ensure all states are engaged alongside New South Wales in improving compliance and enforcement efforts.[155] The report recommended implementing a new NSW Natural Resources Access Regulator created by legislation responsible for water and other natural resources. Such measures would go a long way in restoring public confidence in water reform process. Comprehensive water metering of consumptive water use and water interception across the Basin is required as per the National Framework for Non-urban Water Metering.[156] Metering should be mandatory condition of any licence to extract water for consumptive use, and the 'no metering, no pumping' rule should apply.[155] Opportunities for progressing metering reforms that could be implemented widely in the Basin include technological advancements to improve real time data collection and online access to public data.[157]

A subsequent 2017 compliance review by the Murray-Darling Basin Authority identified failures in the regulatory framework at the Commonwealth level. The review found "the MDBA has not given sufficient attention to compliance, has not provided a clear statement of its compliance role, and has not dealt adequately with allegations of compliance breaches."[152] Water audit monitoring reports and reports by the independent audit group for assessing compliance with extraction limits have not been published by the Murray-Darling Basin Authority since 2010-11 after states withdrew funding for joint programs, and groundwater assessments are not publically available. There are also issues with the models that are used for assessing compliance: (1) use of three non-accredited models and four temporarily-accredited models,[35] (2) lack of up-to-date demand data in model calibration, and (3) possible overestimation of baseline and sustainable diversion limits.[158] As a result, it is not possible for anyone to have confidence that diversion limits are being complied with.

Estimates of consumptive use should be based on metered use against an accredited sustainable diversion limit model for that year, rather than only modelled use for that year. Standard auditing practices should also be in place to validate data on water use, by applying financial reporting, auditing and insurance standards to a water context, and using multiple lines of evidence, such as hydrographs, metering records, aerial imagery and production data. Risk assessments can help focus initial auditing efforts on valleys where risks of non-compliance are high, such as valleys which are poorly metered or remote.

To rebuild public trust with transparency, Commonwealth, state and territory governments should agree to comprehensive measurement of consumptive water use and water interception, including groundwater, across the whole Basin to a standard suitable for compliance action.

2.2 Improve accountability

The Commonwealth Government does not currently have sufficient measures in place to prevent Basin states from gaming the Basin Plan and ensuring recalcitrant states deliver necessary actions. Already, $7.9 billion has been spent with inadequate governance, poor transparency and for unknown returns. Further funding is earmarked for Basin states to implement projects which are not consistent with the requirements of the Basin Plan.[5]

From 2006 onwards, the New South Wales Ombudsman's office has received complaints and public interest disclosures alleging that the water management principles and rules were not being properly complied with and enforced. A formal investigation by the Ombudsman in November 2017 found "underlying structural and systemic problems… including chronic under-resourcing of the compliance and enforcement roles, the constant stream of restructures and transfers of water regulation responsibilities (seven times since 2007) that resulted in significant staff turnover, loss of corporate memory and poor staff morale, and a clash of cultures between a customer service focus and enforcement obligations."[151]

The Commonwealth Government needs stronger measures to ensure states are held accountable for delivering the activities and outcomes required by the Basin Plan. The Murray-Darling Basin Authority's audit program was significantly reduced in 2013 after Basin states withdrew funding from the joint program arrangements.[134] Audit program functions included ensuring monitoring compliance with the 'cap' which limits surface water diversions in the Basin, ensuring water is correctly accounted for when it is traded and conducting a range of independent audits. Water audit monitoring reports and Independent Audit Group reports on cap implementation have not been published since 2011-12.

Annual, public reporting to COAG on a range of aspects of Basin Plan implementation is required, including reporting on progress of water resource plan development, status of pre-requisite policy measures, achievement of Basin Plan targets, addressing risks to water resources, and independent audits of Basin Plan implementation. Reporting on expenditure is also needed, as there is almost no information in the public domain about how the $7.9 billion has been spent, nor assessment of the cost effectiveness or return on investment in terms of the entitlements acquired.

COAG should agree to introduce professional water accounting standards and independent auditing against standards, accompanied by annual audits of expenditure of public funds and annual independent reviews of the Basin Plan's progress.

3.3 Reinstate a basin-wide river health monitoring program

The Australian Government is investing $13 billion to restore "healthy and resilient ecosystems with rivers and creeks regularly connected to their floodplains and, ultimately, the ocean."[159] Governments owe it to the community to demonstrate that these investments are resulting in demonstrable improvements in the condition of the river systems across the Murray-Darling Basin. In 2012, the year parliament adopted the Murray-Darling Basin Plan, the Government abolished the Sustainable Rivers Audit program that was established to measure the condition of the river systems. Governments no longer have evidence of environmental condition to make informed management decisions. It is vital, therefore, that an annual Basin-wide program of condition monitoring is reinstated, based on lessons from the Sustainable Rivers Audit, to monitor the condition of the Basin's environmental assets as a whole, in addition to regular, targeted monitoring of the health of the system to ensure Basin Plan objectives are being met. There is also a need for counter-factual monitoring to assess what would have happened without environmental water for a particular year.

COAG should reinstate a basin-wide river monitoring program to measure and report regularly on the overall condition of the 23 river systems across the Basin as well as targeted programs reporting on progress towards specific Basin Plan objectives against what would have occurred without the Basin Plan.

4.4 Strengthen regulatory capacity

The Water Act 2007 established the Murray-Darling Basin Authority to prepare, implement, enforce and review an integrated plan for the Murray-Darling Basin. The Authority's key regulatory roles are in relation to advising the Minister on the accreditation of Basin State water resource plans that are consistent with the Basin Plan, ensuring accredited plans are complied with, and ensuring there is compliance with trading rules (chapter 12 of the Basin Plan). The Authority is yet to fully exercise their regulatory powers and is currently working with states to implement the Basin Plan including completing the development of water resource plans. However there is a clear need for strengthened capacity as a regulator, not only in compliance but across all aspects of Basin Plan implementation.

An independent review of compliance in the Murray-Darling Basin Authority published in November 2017 found that the "MDBA has the central leadership and coordinating role but has been unable to assert its authority during the development of water resource plans and transition to SDLs; the Australian Government Department of Agriculture and Water Resources (DAWR) and the Basin Officials Committee (BOC) also have important roles which are not being effectively discharged. The Panel notes an underlying lack of acceptance that the Water Act has fundamentally changed roles and responsibilities for management of Basin water resources: it is not business as usual."[152] A 2017 internal review of compliance conducted at the same time by the Murray-Darling Basin Authority recognised that "the MDBA should strongly assert its right to take enforcement action in cases of non-compliance in the face of inaction by states."[152]

As implementation continues, sustainable diversion limits come into effect and water resource plans proceed through accreditation, the Murray-Darling Basin Authority will need to exercise its statutory responsibility as a regulator as required in the Water Act 2007 to ensure states fulfil all obligations to implement the Basin Plan.[160] This will require building the capacity of the Authority as a regulator by, for example, through adequate resourcing and by introducing experienced regulators on the board and within the agency.

We recommend that COAG agrees to strengthen the capacity of the Murray-Darling Basin Authority to fulfil its duties as a regulator.

2. Guarantee recovery of the full 3,200 GL or genuinely equivalent outcomes

The best publicly available estimate suggests that achieving environmentally sustainable level of extractions would require the recovery of between 3,856 GL (high uncertainty) and 6,983 GL (low uncertainty) of surface water from consumptive use.[21] In 2012, the Authority's Board rejected this advice and instead put to the Australian Parliament a Basin Plan for a water recovery target of 2,750 GL by 2019, with a program to recover an additional 450 GL of water by 2024, bringing the total to 3,200 GL. The Basin Plan also allowed for a reduction in water recovery if equivalent outcomes can be achieved, and provided for an increase in groundwater extractions across the Basin by 949 GL.[23]

Proposed changes to surface and groundwater would result in increased long-term extraction volumes and reduced environmental water for river health:

- In October 2017, the Murray-Darling Basin Authority released a draft determination to increase water extraction limits by 605 GL through projects which propose to deliver equivalent environmental outcomes. Our assessment showed only one project should be approved. Eleven projects (representing in the order of 150 to 270 GL water savings) require additional information before a proper assessment can be undertaken. Twenty five projects (in the order of 316 to 436 GL) do not satisfy Basin Plan requirements.[5] See page 51 for more detail.
- Amendments to the Basin Plan tabled in the Senate on November 2017 would increase surface water extraction limits for irrigation by 70 GL in the Northern Basin and increase groundwater extraction limits by 160 GL. This would result in less water available for the environment and reduced likelihood of achieving environmental outcomes in the Basin.[161]
- Some Basin states are attempting to adjust river management rules and change computer model settings in a way that will allow larger volumes of water to be legally pumped for private use (including water that has been recovered for the environment). See page 56 for more detail.

Failure to reach the target of 3,200 GL of water or equivalent outcomes, in addition to the water available prior to the Basin Plan, carries significant risks to the river system. Modelling by the Murray-Darling Basin Authority in 2011 showed recovery of 2,400 GL "was insufficient to achieve a number of key environmental objectives for the River Murray" depriving many ecosystems including the Ramsar-listed Riverland and the Coorong, Lower Lakes and Murray Mouth from sufficient flows.[48] Under this scenario, there will be insufficient end of system flows that are important for exporting salt out of the Basin. There will also be reduced likelihood of inundation across the large majority of floodplains and wetlands that are not served by environmental works and measures.[22] Running the river system on tighter water volumes leaves less room for error and increases vulnerability to climatic and other changes. For these reasons, environmental water remains a vital and superior option to achieve Basin Plan objectives.

Three actions are necessary to ensure the 3,200 GL target is reached: (1) secure the remaining 1,093 GL or equivalent; (2) ensure environmental outcomes are equivalent; and (3) ensure water is being protected in the river and not being undermined by changes to rules, assumptions and models.

2.1 Secure the remaining 1,093 GL or equivalent

It is possible to recover the remaining water in a way that results in measurable additional flows to the river, while supporting communities likely to be adversely impacted by reforms. However, water recovered using infrastructure efficiency upgrades (e.g. lining of channels, conversion of flood irrigation to drip irrigation) may not achieve the anticipated water savings because of the reduction in return flows and groundwater recharge from existing arrangements that would have otherwise benefitted the environment.[162, 163] Impacts on return flows are not currently accounted for by the Commonwealth when investing in on-farm infrastructure upgrades. Accounting for return flows is necessary to guarantee that water savings are genuine and result in additional flows in the river system. Water recovery through purchase may also result in less water savings than expected because of the potential reduction in return flows and groundwater recharge associated with changing patterns of on-farm water use or ceasing of irrigation on a property altogether.

Recovering water through infrastructure upgrades is between two and seven times more expensive than water purchase.[39] Recovering the remaining 1,093 GL of water or equivalent through infrastructure efficiency investment may therefore exceed the available budget. A report commissioned by the New South Wales Government in 2017 estimated that the total cost of recovering 450 GL through on- and off-farm infrastructure could reach $2.4 billion, $600 million more than is available in the Special Account.[129]

A better approach is to offer irrigators capital for on-farm investment to improve farm productivity in exchange for an agreed volume of water entitlements. Projects could include activities such as netting of orchards, new or improved soil moisture monitoring networks, paddock renovation including laser grading and upgraded feedlots, provided they do not result in increased consumption of water. This approach provides farmers with greater flexibility to invest in a wide range of activities that will improve farm productivity, not just irrigation infrastructure upgrades which lock farmers into irrigation and may not deliver the anticipated water savings.

Another approach is to use strategic purchase to recover water for the environment while releasing funds for regional development. Water recovery through voluntary purchase provides farmers with several benefits: flexibility in managing impacts of drought, a pathway to retire from their land, cash flow during drought and improved on-farm water efficiencies.[77, 81] Recovering remaining water through strategic purchase requires lifting the recent 1,500 GL cap on buybacks, and reassigning 450 GL of the water already recovered through existing infrastructure programs towards the program to achieve enhanced environmental outcomes (s7.09 (e) of the Basin Plan).

COAG needs to commit to securing the remaining 1,093 GL or equivalent through a combination of strategic water purchase, water efficiency programs and on-farm productivity investment, but only where such recovery results in measurable additional water to the river system. Water recovered must also account for the reduction in runoff and groundwater recharge that would have otherwise benefitted the environment.

2.2 Ensure environmental outcomes are equivalent in any adjustment to the sustainable diversion limit

The Basin Plan includes an agreement between the Commonwealth and states to allow environmental works and measures to offset the water recovery target through projects which achieve equivalent environmental outcomes (see Chapter 7 of the Basin Plan). New South Wales, Victoria and South Australia have brought forward a package of 37 projects to be considered for a reduction under the sustainable diversion limit adjustment process. This package includes engineering works, changes in river operations, evaporative savings, and enhancements to ease or remove constraints to the delivery of environmental water. The Murray-Darling

Basin Authority has estimated the outcomes that could be achieved by this package is equivalent of up to 605 GL of environmental water.

We have compiled a set of twelve conditions that we believe any proposal submitted for sustainable diversion limit adjustment would need to comply with to meet the Basin Plan and associated requirements (Table 10). Eleven of these conditions were taken from the Basin Plan itself, as well as policies that have been adopted by the Authority. The Wentworth Group has added one further condition which is that any water savings from rules-based projects will be converted into a water entitlement (Condition 8). We believe that all twelve conditions are necessary to ensure projects are designed and operated in a way that is likely to deliver equivalent environmental outcomes.

Table 10. Recommended conditions of approval of supply measure projects proposed by state governments to ensure all projects are operated in line with the requirements of the Basin Plan and related documents.

Condition of Approval	Policy	Source
1. Works-based projects must align with Basin Plan targets.	All works-based project proposals must specify quantitative targets that contribute to outcomes set out in the Basin Plan or Basin-wide Environmental Watering Strategy.[27] The required operating practices and procedures to meet these targets must be clearly specified and consistent with modelling assumptions.	Basin-wide environmental watering strategy [27]
2. All works-based projects must be assessed using a scientifically robust method.	All works-based projects assessed using the agreed Ecological Elements scoring system developed by CSIRO[164] and independently reviewed in 2014. This is the default method specified in Schedule 6 of the Basin Plan that measures whether a project is able to produce equivalent environmental outcomes. Any adjustment must be once-off with no further push to use alternative methods or proposals that do not fall under the default method (e.g. carp herpes, fish ladders and other complementary projects) to justify future reduction in environmental water.	Basin Plan s6.05
3. Any adjustment of the sustainable diversion limit must ensure that there is no change in flow indicators.	There is no change to river flow indicators within the main channel and no more than a 10% change in flow indicators for overbank flows.	Basin Plan s6.07
4. Sustainable diversion limit must not change by more than ±5% overall.	When combined with irrigation efficiency measures, the overall net change in sustainable diversion limit is no more than ±5% across the whole Basin.	Basin Plan s7.19
5. Environmental risks must be mitigated to acceptable levels.	Risks are mitigated to acceptable levels and funded as part of the proposed project, rather than as separate supply measures justifying less environmental water. This includes risks to achieving objectives in the Basin Plan, risks to third parties, adverse water quality and salinity impacts, threats to water-dependent species and ecosystems, risk of invasive species, cumulative risks, and likely effects of climate change over the lifetime of the project.	Phase 1 Assessment Guidelines for Constraint and Supply Proposals, Overarching Evaluation Criteria #4.
6. Long-term governance arrangements must be secured.	The following conditions must be met: 1. Ownership and management responsibilities must be clearly defined and operations and maintenance must be borne by the owner; 2. Projects must be independently audited and periodically re-licenced; 3. Funding must be committed in advance for ongoing operation, risk mitigation measures, long-term monitoring and auditing; and Agreement must be secured from landholders affected by the project (e.g. by acquiring easements, upgrading roads or building bridges to enable delivery of flows), and if necessary, the existing state and Commonwealth legislation should be used to achieve constraints targets specified in the Constraints Management Strategy.[165]	Phase 1 Assessment Guidelines for Constraint and Supply Proposals, Overarching Evaluation Criteria #3.

7. Environmental water must be able to reach works projects and the broader floodplain in the future.	Proposed projects must be able to operate (1) in a natural way with all structures open during regulated and unregulated river flows, and (2) under a range of future water availability scenarios, based on an assessment of climate change impacts. The use of environmental works should not substitute for the aim of watering the broader floodplains and wetlands to achieve the outcomes in the Basin-wide Environmental Watering Strategy.	Basin-wide environmental watering strategy [27]
8. Any water savings from rules-based projects will be converted into a water entitlement	Any water savings from rules-based projects should be converted into a water entitlement. The entitlement should be issued to the environment by the proponent of the proposal that is environmentally equivalent to the claimed water savings to ensure the savings will be realised in the real world.	Recommended in a report commissioned by MDBA "Converting savings to licence entitlements is required to achieve a supply contribution" [166]
9. Projects must deliver value for money.	Projects estimated to cost more than $1,900 per megalitre should not be approved as per the *Intergovernmental Agreement on Implementing Water Reform in the Murray-Darling Basin*.	*Intergovernmental Agreement on Implementing Water Reform in the Murray-Darling Basin*, and Phase 1 Assessment Guidelines for Constraint & Supply Proposals, Overarching Evaluation Criteria #2
10. Projects must be monitored to ensure outcomes are delivered.	Careful monitoring of projects is needed to ensure the outcomes match what was expected, starting with a review of existing The Living Murray projects against their expected outcomes. If there are discrepancies that cannot be addressed by management actions, a review of sustainable diversion limits will be required.	Basin-wide environmental watering strategy [27]
11. Projects are consistent with the Constraints Management Strategy. Constraint levels as at 2012 must be used as a benchmark to compare changes.	Constraint levels at 2012 in Table 13, as described by the Murray-Darling Basin Authority,[147, 167] should be used as the benchmark as they represent flow rates that could be delivered at the commencement of the Basin Plan according to state water sharing plans and state and Commonwealth river operators. Any illegal constraints (e.g. unlicenced levees) should be removed.	Constraints Management Strategy, Phase 2 Assessment Guidelines for Supply & Constraint Measure Business Cases #3.2.2
12. Pre-requisite policies proposed by states for managing environmental water must be configured in the model used to calculate an adjustment.	Prerequisite policy measures for crediting return flows and calling environmental water from storage (s7.15 (b) (ii), including shepherding arrangements) proposed by states should be configured into the model when calculating the adjustment to the sustainable diversion limit, to avoid the risk that policies presented by Basin governments do not enable the same outcome as the benchmark model for sustainable diversion limit adjustment.	Basin Plan s7.15 (1) (ii)

The Wentworth Group has undertaken an analysis of the 37 projects against these twelve conditions.[5] For this analysis, we used information available on government websites and business cases provided by the Victorian and South Australian Governments. The New South Wales Government declined our request for business cases.

For each project, we determined whether the conditions were met, conditions were not met, further information was required, or the conditions were not applicable. On the basis of this assessment, we have identified those projects that meet all conditions and should be approved; those projects where further information is required; and those projects that should not be approved in their current form.

The results for each project are summarised in Table 11. Our assessment shows that:

1. Only one project, the *South Australian Murray Key Focus Area* meets the necessary conditions for approval. Approval of this project for adjusting the sustainable diversion limit is however, contingent on upstream constraints proposals meeting targets in the Constraints Management Strategy.

2. Eleven of the projects (representing in the order of 150-270 GL water savings) require additional information before a proper assessment can be undertaken. With such information it might be possible for some or all of the projects to satisfy the 12 conditions for approval. However, all projects would need to ensure there is no significant change in environmental flows reaching the Lower Lakes and Coorong (Condition 3).
3. Twenty five projects (representing in the order of 316-436 GL) do not satisfy these conditions and should not be approved in their current form. This includes The Living Murray works which, although they are able to be considered for a sustainable diversion limit adjustment, they are not likely to result in equivalent environmental outcomes because of the environmental risks identified.

In addition, of the six nominated constraints proposals, three were not consistent with the Constraints Management Strategy and should not be considered in the sustainable diversion limit adjustment determination (Table 11 and Table 13). Constraints measures are, however, essential to the successful implementation of the Murray-Darling Basin Plan. Constraints proposals need to be modified in line with the Constraints Management Strategy and funding should be reallocated to support the amended projects.

Table 11. Assessment of projects based on twelve conditions necessary for delivering the Basin Plan outcomes.

Project	Estimated Adjustment (GL)
1. Projects that should be approved	0
• South Australian Murray key focus area	
2. Projects requiring further information	195-340
• 2011 Snowy Water Licence Schedule 4 Amendments to River Murray Increased Flows Call Out Provisions • Computer Aided River Management (CARM) Murrumbidgee • Flexible Rates of Fall in River Levels Downstream of Hume Dam • Hume Dam airspace management and pre-release rules • Structural and operational changes at Menindee Lakes and Lower Darling key focus area • South East Flows Restoration Project • Flows for the Future • Hume to Yarrawonga key focus area • Murrumbidgee key focus area • Murray and Murrumbidgee Valley National Parks SDL Adjustment Supply Measure • Nimmie Caira Infrastructure Modifications Proposal	
3. Projects that should not be approved	271-366
• Barmah-Millewa Forest Environmental Water Allocation • Enhanced environmental water delivery (Hydro Cues) • Improved Regulation of the River Murray • SDL offsets in the Lower Murray NSW • Yarrawonga to Wakool junction key focus area • New Goulburn key focus area • Lindsay Island (Stage 2) Floodplain Management Project • Wallpolla Island Floodplain Management Project • Belsar-Yungera Floodplain Management Project • Guttrum and Benwell State Forests Floodplain Environmental Works Project • Hattah Lakes North Floodplain Management Project • Gunbower National Park Floodplain Management Project • Burra Creek Floodplain Management Proposal • Nyah Floodplain Management Project • Vinifera Floodplain Management Project • Gunbower Forest TLM Project • TLM environmental works and measures – Koondrook-Perricoota Forest Flood Enhancement proposal	

- Mulcra Island Environmental Flows TLM Project
- Lindsay Island (Stage 1) Upper Lindsay watercourse Enhancement TLM Project
- Hattah Lakes Environmental Flows TLM Project
- Chowilla Floodplain TLM Project
- Improved Flow Management Works at Murrumbidgee River – Yanco Creek Offtake
- Modernising Supply Systems for Effluent Creeks – Murrumbidgee River
- Riverine Recovery Project
- South Australian Riverland Floodplain Integrated Infrastructure Program (SARFIIP)

Broadly, environmental works projects were a simplistic engineering response designed to divert water from river channels into a prescribed landscape to produce a limited suite of hydrological outcomes mainly for eucalypts. Works projects had little regard for the wide range of water requirements for river health, with inevitable risks on third parties and the environment that could reduce or cancel out their benefits. There was a lack of scientific precedent for achieving their stated benefits. The following risks were common to works projects we assessed:[168]

1. Adverse water quality impacts when water ponded on floodplains eventually returns to the channel (salt migration; anoxic blackwater; eutrophication);
2. Poorly defined project governance arrangements considering the complex planning, operational and management procedures that will involve the collaboration and cooperation of Federal and State government agencies, e.g. who will own and pay for operations and maintenance of infrastructure;
3. Private land impacts from flooding are known for five of the Victorian projects, with no comprehensive assessment of third party impacts for another two projects;
4. Increases in carp and other pest fish species are a risk for all of the projects assessed;
5. Stranding of native fish during/after watering or lack of flow cues for exit. General adverse impacts on ecological function and connectivity for aquatic species;
6. Limited protection of outer floodplain communities, like black box floodplain forests, failing a key conservation principle for representative conservation of different ecosystems;
7. Demands on water infrastructure design to operate effectively through a wide range of hydrological regimes including under climate change (even though climate change projections have not been used in their design). Associated episodic reduction in hydrodynamic diversity (e.g. lentic habitat creation, prolonged inundation of vegetation);
8. Finalisation of infrastructure design (see above point), construction and ongoing operation and maintenance cost and ownership have not been addressed in business cases. Smaller projects are likely to yield a low supply volume benefit at very high cost. Plausible supply contribution for nine Victorian environmental works and measures projects was estimated at 40-50 GL with a moderate certainty;[166]
9. Works projects may compete for available environmental water with other works projects. It is also possible that some non-works proposals could compete for water;[166] and
10. Questionable value for money in terms of the volume of water saved for many individual projects.
11. 'Complementary measures' such as carp herpes virus, fish ladders, water quality management and thermal pollution control devices are important for river restoration, however these measures should not be substituted for the recovery of environmental water.

We recommend the Murray-Darling Basin Authority adopt the conditions of approval set out in Table 10 to ensure environmental outcomes are equivalent or better, and consistent with the Basin Plan. On the basis of our assessment of projects against these conditions, we recommend that the Murray-Darling Basin Authority should:

1. **Approve the *South Australian Murray Key Focus Area* project;**
2. **For those projects that don't satisfy the necessary conditions, the proponent should be invited to demonstrate that conditions can be met prior to approval for funding and SDL adjustment; and**
3. **Projects that fail to meet the conditions should be removed from the SDL adjustment determination and should not proceed to implementation.**

In addition, of the six nominated constraints proposals, three were not consistent with the Constraints Management Strategy and should not be considered in the SDL adjustment determination. Constraints measures are, however, essential to the successful implementation of the Murray-Darling Basin Plan. Constraints proposals need to be modified in line with the Constraints Management Strategy and funding should be reallocated to support the amended projects.

2.3 Ensure water recovery is not being undermined by changes to rules, models and assumptions

The Basin Plan can only be effective if it delivers an additional 3,200 GL of water or equivalent outcomes which provide real, long-term benefits to the river system. We identified four potential risks water recovery that may undermine the Basin Plan's effectiveness:

1) Inadequate protection of environmental water;
2) Growth in water extractions, including increases in groundwater, floodplain harvesting and unregulated flows;
3) One-sided reviews of hydrological models; and
4) Rules in water resource plans that would reduce availability of water in the river system.

2.3.1 INADEQUATE PROTECTION OF ENVIRONMENTAL WATER

Environmental water is not well protected by existing water management rules and even when the Basin Plan is in place, environmental water in the river may be vulnerable to illegal extraction, reducing the overall volume of water that is available to achieve environmental outcomes in the Basin.[29] While illegal extraction of environmental water is an obvious threat, there are also many different ways in which environmental water can be taken legally with adverse consequences for the river system (Box 2).

Box 2. Types of legal take of environmental water.

- **Unregulated rivers:** Environmental water in unregulated rivers are left instream and can elevate river levels. Raised levels can trigger pumping thresholds, placing environmental flows at risk of extraction.
- **Regulated rivers:** Environmental water in regulated rivers is ordered from dams or actively delivered to achieve specific outcomes. River operators determine how much water to release by taking into account irrigation demand, environmental needs, tributary flows and predicted losses (i.e. evaporation and seepage). If operators underestimate requirements and the full amount of consumptive water is taken, the volume of unregulated flows and any environmental water in channels will be reduced.
- **Interconnected valleys and across borders:** Once environmental water leaves a valley and flows downstream (e.g. in tributaries to the Barwon-Darling), it may contribute to the unregulated pool of flows and without shepherding rules, lose its status as environmental water. These flows may be extracted by irrigators subject to entitlement conditions, or reach a dam or state/territory border where they may be allocated for other purposes (e.g. Menindee Lakes).
- **Groundwater:** Groundwater flows cannot be ordered or actively delivered, they remain in the aquifers after consumptive take and thus at risk of being extracted.
- **All systems:** Water ministers may have discretion to reverse embargos to extraction, or declare flow events available for consumption. Environmental flows are also vulnerable during critically dry periods when water plans are switched off.

It is not known how much environmental water is legally extracted, but all the examples in this Box have already taken place and, without any intervention, could happen again. Currently, both held (entitlement-based) and planned (rules-based) environmental water may be legally extracted. Planned environmental water is particularly vulnerable because volumes are difficult to account for.[169] This is despite the National Water Initiative, the Water Act 2007 and the Basin Plan all including specific provisions to protect planned environmental water.

The Barwon-Darling river system is one region where environmental water is known to be vulnerable to legal extraction. The 2012 Barwon-Darling Water Sharing Plan contains no event-by-event based protection of environmental flows. That is, environmental water from tributaries is be able to be legally taken by irrigators if they comply with specified pumping thresholds. Nine weeks before the Basin Plan was passed in 2012, the New

South Wales Government made several changes to the Barwon-Darling Water Sharing Plan to increase the volume water that can be pumped for irrigation. These include tripling the volume of water that can be extracted under some entitlements, and allowing for unlimited carryover. The Murray-Darling Basin Authority acknowledged these changes may have reduced the protection of low flows,[170] by allowing irrigators to pump larger volumes of water and take advantage of elevated water levels as a result of environmental water arriving from Queensland and rivers of northern New South Wales. It is only over the long-term where this additional diversion results in a breach of the sustainable diversion limits. These long-term diversion controls will be ineffective at protecting many flow events containing environmental water purchased, particularly low flow events.

Safeguards and permanent rules need to be in place to protect environmental watering events (both held and planned environmental water) from extraction, and ensure that increased river flows resulting from environmental water do not trigger increased diversions. Sustainable diversion limits alone do not protect environmental watering events because they are long-term average extraction limits. Permanent arrangements must also be in place to protect environmental water on an event-by-event basis, in water resource plans or via agreement between states. Options include applying conditions on water entitlements, embargoes on extractions during environmental watering events, 'shepherding' flows through valleys and over borders (where an equivalent volume of environmental water available upstream is re-allocated at a downstream location), adjusting pumping thresholds, and short-term extraction limits that restrict the volume of take over a short period of time.

When the Basin Plan was negotiated, states agreed in principle to revise their water management rules to include rules to protect environmental water in line with the Basin Plan, on the proviso that there will be no changes to the reliability of water available under entitlements.[171] This proviso provided water users with assurance that the reliability of water entitlements would not be eroded under the Basin Plan, giving certainty to investors. However, it also meant that states could be exempt from including rule changes which affect reliability (both increase and decrease). Under a narrow interpretation, the reliability clause has the potential to release states from their water resource plan obligations, including those for the protection of environmental water. For effective protection of environmental water, the Murray-Darling Basin Authority should clarify their interpretation of the reliability clause[172] when reviewing water resource plans and the onus of proof should be on states to prove there will be an impact on reliability.

COAG should ensure that:

1. **There is no net reduction in 'planned' environmental water, including spills, as required by the Water Act 2007 and Basin Plan (see Table 12 Safeguard 1 for details).**
2. **All environmental water ('planned' and 'held' under entitlement) is protected within and between valleys, including over state borders (see Table 12 Safeguard 2 for details).**

2.3.2 GROWTH IN SURFACE AND GROUNDWATER EXTRACTIONS

Plantations, runoff dams, commercial forestry, mining, coal seam gas and other activities pose significant risks to surface and groundwater reserves in the Basin. The Bureau of Meteorology estimated that the volume of runoff harvested by farm dams alone was 2,037 GL in New South Wales, South Australia and Queensland in 2015-16, or 12% of the total annual water use.[69] A 2010 report for the National Water Commission estimated that interception activities could amount to a quarter of all entitled water on issue.[173]

Basin states are required to report on the quantity of water taken from a water resource unit each water year (s71 of the *Water Act 2007*), including water taken from interception activities. However, there is little progress on estimating the water taken through interceptions.[174] Improved and up to date estimates of interception activities are required to ensure compliance with sustainable diversion limits for surface water and groundwater.

The Murray-Darling Basin Authority should also have procedures in place for identifying and managing increases in water interceptions including floodplain harvesting, growth in water use, and risks from shifting of diversions to other water sources (e.g. groundwater). These should also recognise links between groundwater and surface water, because managing surface and groundwater resources conjunctively in the future is critical. There is evidence that some water users with access to suitable quality groundwater have used it as a drought reserve, substituting groundwater for surface water in periods of reduced surface water availability.[71, 175] Rules in water resource plans are needed to manage risks to groundwater during dry periods given the increased demand and the need to preserve the productive base of groundwater (s10.20 of the Basin Plan).

Future impacts of groundwater use on surface and groundwater quality and quantity are likely to increase with growth in mining activities. For example, the New South Wales Government estimated that future demand for water in the Western Porous Rock unit will triple with the development of four proposed mines.[176,177] The Authority is now proposing to increase the sustainable diversion limits for three groundwater areas within the Murray-Darling Basin by a total of 160 GL, and make a number of changes to the way groundwater is managed under the Basin Plan. Sufficient evidence must be in place to demonstrate the capability of states to manage uncertainty and current and future risks to water resources prior to changing sustainable diversion limits.

COAG should ensure that water recovery is not being undermined by growth in extractions (see Table 12 Safeguard 3 for details).

2.3.3. POTENTIAL FOR ONE-SIDED REVIEWS

The Basin Plan enables the Murray-Darling Basin Authority to revise the sustainable diversion limits on the basis of new evidence or improved methods.[178] These reviews, however, are susceptible to bias that needs to be appropriately mitigated to ensure estimates are valid and fit for purpose. Selection bias can occur when evidence is cherry-picked rather than brought forward as part of a comprehensive assessment. As part of the Northern Basin Review in 2016, the Murray-Darling Basin identified two valleys - the Macquarie and Gwydir Rivers - as “over-recovered” because of planning assumptions which under-valued some entitlements.[179] The Murray-Darling Basin Authority stated that “revised planning assumptions in the northern Basin are likely to result in an increase of approximately 31 GL in the value of entitlements currently recovered”.[179] Had similar review been conducted across all rivers of the Northern Basin, it may have found a different outcome. A submission by the Macquarie Marshes Environmental Landholder Association to the Murray-Darling Basin Authority in 2017 stated that the landholders “remain fearful that allocations can be manipulated to favour one group of water users over another.”[180] The only way to overcome the risk of selection bias is by ensuring reviews are conducted in a systematic, robust and transparent way for all valleys against standards, and are subject to independent oversight.

All models used to inform decisions should be up to date and accredited against standards. There should be no change to the baselines, rules and assumptions without a systematic, independent and publicly available review (see Table 12 Safeguard 4 for details).

2.3.4 RULES IN WATER RESOURCE PLANS SHOULD NOT REDUCE AVAILABILITY OF WATER IN THE RIVER SYSTEM

The Basin Plan requires states to prepare water resource plans which comply with Basin Plan requirements in order for these plans to be adopted and accredited (Chapter 10). This may require states to make changes to existing rules in water resource plans. Some proposed changes may result in backsliding on the current level of protection of environmental water, unregulated flow and dam spills. For example, the New South Wales Environmental Defenders Office has identified the risk of backsliding on environmental water protections and compromising environmental outcomes as a result of potential rule changes being considered for the Gwydir Water Resource Plan: (1) reducing carryover from 200% to 150%, (2) changes to the ‘3T minimum flow rule’,(3) increased flexibility for some entitlement holders, and (4) review of mandatory conditions on entitlements and approvals.[181] Potential risks have also been identified in the process of accrediting the Namoi Regulated River Water Sharing Plan where the New South Wales Government is proposing to allow for an increase in the share of supplementary water for extractive use. The current rules specify a 90:10 sharing of supplementary water access for the environment and extraction respectively, while the proposed rule is a 50:50 sharing provided there is no growth in use. Growth in use is a weak safeguard because it is difficult to quantify and can only be enforced retrospectively.

The Murray-Darling Basin Authority should produce standards for accreditation of water resource plans that are consistent with Basin Plan requirements and model assumptions. Water resource plan rules should be assessed against standards using hydrological modelling. Accreditation needs to be subject to independent and public review (see Table 12 Safeguard 5 for details).

This requires adopting the safeguards in Table 12 to ensure water recovery is not undermined by changes to state water resource plans, river management and operating rules, changes to baselines or model assumptions, and other land use changes that affect water availability in the catchments (e.g. farm dams, plantations, floodplain harvesting).

Table 12. Safeguards to ensure that any changes to state water resource plans, river management and operating rules, or changes to baselines or model assumptions do not undermine the water recovery effort.

Safeguard	Policy
1. No net reduction in 'planned' environmental water.[182]	There must be no net reduction in 'planned' environmental water as required by the Water Act 2007 and Basin Plan. COAG should agree to a definition of planned environmental water that includes dam spills and unregulated river flow. • The Authority must be satisfied the volume of planned environmental water in each valley under proposed water resource plans is equal to or greater than the volume of planned environmental water in each valley before the commencement of the Basin Plan. • The Authority should not interpret the reliability clause (section 6.14) in a way that would release states from their water resource plan obligations under the Basin Plan. Instead, the effects of any changes to plans, operating rules or baselines should be managed in a way that is consistent with the National Water Initiative Risk Assignment principles. The onus should be on states to prove there is an impact on reliability.
2. All environmental water ('planned' and 'held' under entitlement) must be protected within and between valleys, including over state borders.	Prior to accrediting a state water resource plan, the Murray-Darling Basin Authority must be satisfied that environmental water (both held and planned) can be delivered without risk of en-route extraction, and without triggering other extractions. This requires permanent arrangements in water resource plans or via agreement by Basin jurisdictions, including: 1. Embargoes on extractions during environmental flow events; 2. Flow 'shepherding' arrangements, allowing an equivalent volume of environmental water available upstream to be re-allocated at a downstream location (including within and between valleys and over borders); and 3. Short-term (e.g. daily) extraction limits, pumping thresholds and other rules that restrict the volume of take to protect environmental flow events.
3. Water recovery must not be undermined by growth in extractions.	To guarantee water recovery results in additional water in the Basin, the following must be ensured: 1. Any growth in water intercepted by farm dams, commercial plantations or water taken under a riparian right must be offset by a reduction in consumptive water use (s10.13 in the Basin Plan), requiring improved and up to date estimates of the scale and impacts of interception activities; 2. Risks to water interceptions resulting from mining activities including coal seam gas mining, and floodplain harvesting are managed to ensure they do not compromise environmental outcomes (s10.23 – 10.25); 3. Water resource plans must include rules to preserve the productive base of groundwater (s10.20); and 4. The activation of underused water entitlements (i.e. sleeper and dozer licences) is reviewed to ensure models accurately reflect expected utilisation over the life of the Plan.
4. All models used to inform decisions should be up to date	Without this policy, there is a risk of incremental changes to rules or assumptions in the flow models without appropriate scrutiny,

and accredited against standards. There should be no change to the baselines, rules and assumptions without a systematic, independent and publicly available review.	undermining the goal of recovering water for the environment. Any change to the accredited models for assessing the baseline diversion limit (MDBA Baseline Model Run 2012) and sustainable diversion limits (model not yet assessed) should therefore require independent review. This includes changes to assumptions which influence the reliability of water available under entitlements. Modelled sustainable diversion limits for that year should be compared with actual metered use to assess compliance.
5. Accreditation of water resource plans should be subject to independent and publicly available review.	This policy is aimed at reducing the risk of changes to state water resource plans that result in an increase in the quantity of unregulated flow or dam spills that can be taken for consumptive use.

3. Ensure that water recovered achieves measurable improvements to the river system

Once environmental water is allocated in a river system, it is essential that is then able to reach the target location to achieve the desired outcomes. This review has identified four risks that could prevent the delivery of flows to the target location: (1) physical constraints and policy actions which impede the delivery of water to floodplains and wetlands; (2) challenges of providing sufficient flows to the Coorong, Lower Lakes and Murray Mouth; (3) the risk that environmental water outcomes are omitted from regional watering plans and (4) risks of water theft and inadequate compliance. We discuss the first three risks in this section and the fourth risk in the section on page 47.

3.1 Constraints to the delivery of flows

Flow constraints are physical barriers or policy actions which impede the delivery of water to floodplains and wetlands. They are among the most frequently cited challenges affecting the delivery of environmental water under the Basin Plan to date. They included operational constraints,[94, 117, 118] channel capacity constraints,[183] access to irrigation pumps,[184] crop harvesting, [94, 185] maintenance work,[103, 117] even a water skiing event,[183] cod fishing,[184] and other third party impacts.[113] Key constraint areas identified by the Murray-Darling Basin Authority were on the upper Murray River from Hume to Yarrawonga, mid-Murray River from Yarrawonga to Wakool Junction, Goulburn River, Murrumbidgee River, Lower Darling River, Gwydir River and on the lower Murray in South Australia.[165] These constraints are preventing environmental water from passing across low-lying areas next to watercourses and in designated floodways below minor flood levels.

In 2012, the Commonwealth Government committed $200 million to address physical, institutional and operational constraints over ten years from 2014/15.[186] A key focus of the Murray-Darling Basin Authority's Constraints Management Strategy in 2013 was addressing the constraints to the delivery of overbank flows into South Australia, and allowing environmental watering of floodplain wetlands in the mid-Murrumbidgee and the lower Goulburn River at higher flow rates than were achievable in 2012.

Modelling by the Murray-Darling Basin Authority in 2012 showed that a flow of 80,000 ML/d into South Australia was needed to provide sufficient water to enable 75% of wetlands and flood dependent vegetation in South Australia to be inundated, compared to just 40% with the river system constraints possible in 2012 (Figure 31).[167] This target is necessary to allow environmental water to reach the floodplain forests, maintain connection between the river and the floodplain (Basin Plan s5.02) and achieve better outcomes with the water available. On the basis of the modelling, the Murray-Darling Basin Authority identified the flow targets for each key constraint area, which reflected the minimum flow rates required to achieve outcomes in the Basin-wide Environmental Watering Strategy[27] and in Schedule 5 of the Basin Plan.

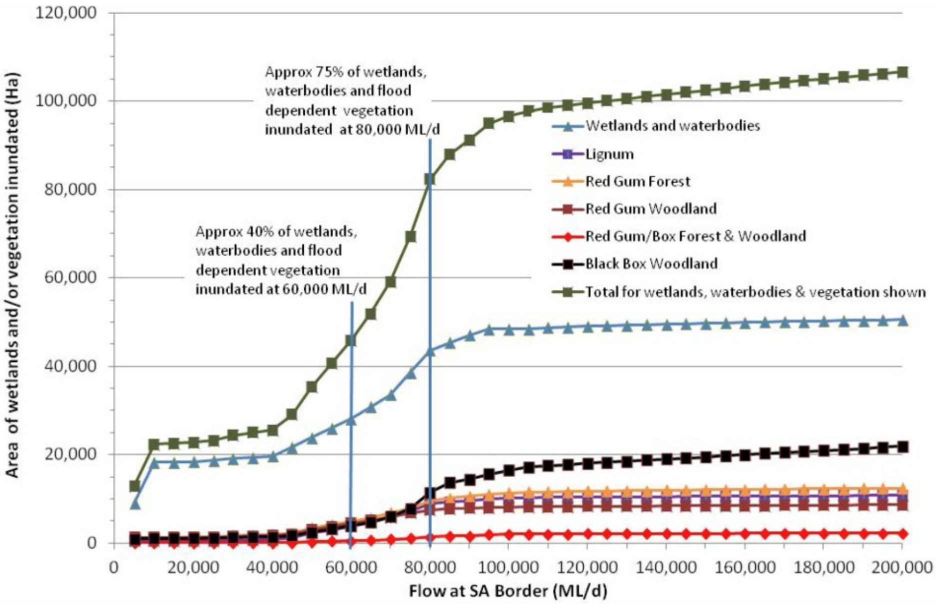

Figure 31. Relationship between inundation of wetlands and flood-dependent vegetation and flow at the South Australian border (Source: MDBA 2012)

In mid-2017, Basin states put forward projects which would alleviate constraints identified in the key constraint areas. Table 13 shows the major constraints existing in 2012, the level of constraint relaxation required by the Constraints Management Strategy, and the constraint levels achieved by the measures proposed by Basin states.

The level of constraint relaxation being proposed by Victoria and New South Wales (Table 13) is not sufficient to achieve the aims of the Constraint Management Strategy or the enhanced environmental outcomes in Schedule 5 of the Basin Plan. In some cases the proposed constraint levels represent a return to what could be delivered prior to the Basin Plan, reflecting the fact that constraints in these areas have worsened since the Basin Plan came into effect in 2012.

Of the six nominated constraints proposals submitted for assessment under the sustainable diversion limit adjustment mechanism, only three were found to be consistent with the Constraints Management Strategy. Constraints proposals that do meet the targets should not be considered in the adjustment determination. These measures are, however, essential to the successful implementation of the Murray-Darling Basin Plan. Constraints proposals need to be modified in line with the Constraints Management Strategy and funding should be reallocated to support the amended projects.

Without addressing the identified constraints, it will be difficult for environmental water holders to deliver water to key floodplains and wetlands in the southern connected system to achieve the Basin Plan objectives. If constraints are not relaxed to allow higher flow levels than could be delivered in 2012, there is a risk that environmental water holder will not be able to deliver overbank flows and will have to use their environmental water at low flow rates inside the river channel all year round. This will deprive, for example, 35,000 ha of floodplain wetlands in South Australia from receiving environmental water and compromise the Basin Plan outcome of "healthy and resilient ecosystems with rivers and creeks regularly connected to their floodplains and, ultimately, the ocean."[159, 165]

Table 13. Physical constraints that must be addressed to permit delivery of water to floodplains and wetlands in the southern Murray-Darling Basin. Constraints highlighted in red are those projects proposed by states that will fail to meet the Murray-Darling Basin Authority's target in the Constraints Management Strategy.

Region	Location	PRE-BASIN PLAN: Constraint in 2012[165] (ML/d)	TARGET: Target in MDBA Constraints Management Strategy (ML/d)	PROPOSED BY STATES: Constraint in business case[187] (ML/d)
Murray	Hume to Yarrawonga	25,000	40,000	40,000
	Downstream of Yarrawonga	40,000 (but effectively 22,000* due to upstream constraint of 25,000)	40,000 (50,000 for reaching disconnected wetlands and ephemeral creeks)[188]	30,000
Darling	Weir 32/Increase Menindee outlet capacity	9,300	18,000	14,000
	Darling anabranch	Water flows into anabranch over 9,300ML/d	Regulator added & closed above 9,300ML/d when env. water is supplied from Menindee	n/a
Murrumbidgee	Gundagai	30,000	50,000	40,000 at Wagga (~30,000 at Gundagai)
	Balranald	9,000	13,000	9,000
Goulburn	Seymour	12,000	15,000	n/a
	McCoys Bridge	20,000	40,000	20,000***
Total flow at SA border		66,000**(assuming 26,000 from Goulburn)	111,000** assuming Menindee allowed 18,000	78,000**

*10,600 ML/d in regulated periods in summer and in other periods Hume to Yarrawonga constraint of 25,000 ML/d was in place meaning that flows downstream of Yarrawonga were effectively restricted to 22,000 ML/d.
**This number assumes perfect co-ordination of flows between the Murray and tributary flows, something which is highly unlikely. The 111,000 ML/d target is most likely to achieve the outcomes in schedule 5 of the Basin Plan.
***Target was revised down from the 25,000 ML/d to 20,000 ML/d in 2017 by the Victorian Government.[189]

The current 'good neighbour policy'[190] (where environmental water holders seek landholder approval for the passage of environmental flows on private property) is desirable but it cannot guarantee the passage of critical flows for the environment. Permanent solutions are required, including acquiring rights to inundate floodplain land through covenants and easements to compensate landholders for any reduction in land value , while enabling landholders to use their lands for flood resilient activities, such as grazing and timber production.

Once all reasonable options are exhausted, existing state and Commonwealth legislation or new legislation should be used, either by compulsory acquisition of easements, or by upgrading roads and building bridges – as would occur with any other public infrastructure program.

Constraints (physical and policy) that restrict the use or passage of environmental water to target floodplains and wetlands need to be removed to achieve targets in the Constraint Management Strategy (Table 13). This requires re-configuring infrastructure, negotiating flood easements with landholders, enforcing planning restrictions in designated floodways, and where appropriate compensating for any third party impacts.

3.2 Providing sufficient flows to the Lower Lakes, Coorong and the Murray mouth

3.2.1. AN OPEN MURRAY MOUTH

Analysis by the Wentworth Group with the assistance of experts in the South Australian Department of Environment and Natural Resources showed that the commitment made by Parliament in 2012 that the Basin Plan would ensure "the mouth of the River Murray is open without the need for dredging in at least 95% of years, with flows every year through the Murray Mouth Barrages" is, beyond reasonable doubt, impossible. We estimate that the mouth will remain closed in 9 of every 10 years without intervention. This has implications for the ability to export salt into the ocean. It also means less tidal exchanges to support the health of the Coorong and comply with Australia's international obligations under the Ramsar Convention.

Since at least 2002, dredging has been needed to keep the Murray mouth open except during major flood events, as occurred in 2010/11 and 2016/17. The reason for the discrepancy between the Basin Plan objective and observations is that the modelling underpinning the Basin Plan did not incorporate information related to marine processes affecting the Murray Mouth. Consequently, the percentage of time the Murray Mouth will close was grossly underestimated. The only way to maintain an open Murray mouth is additional environmental flows, permanent dredging, and/or some other longer-term large scale physical re-structuring of the entrances to the Coorong and Lower Lakes.

3.2.2. LAKE LEVELS AND BARRAGE FLOWS

Water must be delivered to the Lower Lakes in sufficient volumes to continue to achieve the Basin Plan targets for water levels above 0m AHD and within the range of 0.4m to 0.75m AHD in 95% of years. These targets have been met over the last 7 years and need to be maintained during prolonged dry periods to minimise the risk of acidification of Lower Lakes.

If we accept the proposition that rivers die from the bottom up, then it is necessary for the River Murray at Wellington to convey sufficient water into Lake Alexandrina on a near-continuous basis. If less than 2 GL/day is discharged into the Lake over a protracted period of time, as was the case in the Millennium drought, then evaporation and other losses will lead to lake water levels falling below the MDBA targets, and deteriorating water quality in the Lower Lakes and Coorong estuary.

At least 2 GL/day (about 700 GL/yr long term average) is required to offset net losses to maintain water levels within the target range for the Lower Lakes, but this provides for no barrage or fishway releases to the Coorong and Southern Ocean. To achieve minimum desired outflows at the barrages into the Coorong a higher inflow is needed, in the order of 4 GL/day at Wellington. When higher barrage flows supported by unregulated flow or environmental water delivery are not possible, near-continuous barrage releases in the order of 2 GL/day assists in maintaining estuary conditions in the Coorong and with maintaining an open Murray mouth (Andrew Beal, *pers. comm*., Director, River Operations, DEWNR).

The Basin Plan does not specify minimum flow requirements for the Lower Lakes, so delivering minimum flow requirements to the Lower Lakes should be a key priority of water holders during drought periods to avoid lake levels dropping below 0m AHD and triggering a repeat of the environmental crisis of the millennium drought. It is also critical that constraints in the Lower Darling and River Murray are addressed in line with the Constraints Management Strategy, to allow water holders to take advantage of greater storage capacity in New South Wales and Victoria as a way to improve flow reliability to the Lower Lakes.

A further consideration is ecological requirements of the Ramsar wetlands. Stewardson and Guarino (2016) concluded that "the current management regime appears to prioritise high lake water levels over maintenance of flows to the Coorong and Murray mouth."[3] The operation of barrages needs to be adjusted so that flushing into Coorong occurs at times to best meet ecological requirements of the Ramsar wetlands.

3.2.3. LONG-TERM MANAGEMENT

The Basin Plan contains a number of other objectives for the end of the system, including water quality and salinity targets. Some of these are not yet met and require a review of management practices to ensure the end of the system can be maintained as a healthy, functioning (Ramsar listed) estuary and allow the export of salt accumulating in the river. There are other issues that need to be addressed in future reviews, particularly the long-term impacts of sea level rise affecting the import of sand into the Murray mouth and seepage of sea water through the barrages and into the lakes.

1. Sufficient water flows are required to export two million tonnes of salt over the barrages per year on average. The Murray-Darling Basin Authority's modelling showed that 3,200 GL of water recovery in the Basin will achieve this objective, while water recovery of 2,400 GL and 2,800 GL was likely to be insufficient to meet this objective.[147] It is unlikely that the salt export objective will be met under the current level of water recovery (2,107 GL) or the levels proposed by the Murray-Darling Basin Authority following the proposed adjustment of the sustainable diversion limits.
2. Current dredging operations involves the disposal of sand from the Murray mouth channel into discharge locations on either side of the mouth. This sand is available for redistribution back into the mouth during periods of relatively low barrage flow. Dredge spoils will need to be relocated to sites where coastal processes are unable to return the sand back to the mouth.
3. Adverse impacts of climate change on water availability in the Murray-Darling Basin along with potential impacts of sea level rise will have implications for management of the Lower Lakes, Murray mouth, Coorong and barrage operations.

Governments need to ensure sufficient water reaches the Lower Lakes, Coorong and Murray Mouth to export salt from the Basin, reduce water quality risks, and deliver freshwater to maintain the ecological character of the Ramsar wetlands. This requires:

1. **Sufficient inflows into the Lower Lakes during dry periods to meet water level targets and reduce the water quality risks.**
2. **Management of upstream constraints in line with the Constraints Management Strategy to allow for flows of sufficient volume and timing to reach the end of the system.**
3. **Agreement should be reached by responsible government agencies on priorities for the Lower Lakes, Coorong and Murray mouth, taking into consideration the need to protect the Coorong Ramsar site and export salt through the mouth.**
4. **Assurance from the Murray-Darling Basin Authority that the objective for salt export will be achieved following adjustment to the sustainable diversion limits.**
5. **An ongoing dredging program because of the power of the sea to bring sand into the mouth.**
6. **Review of the placement of dredge spoil to reduce the return of sand to the Murray mouth.**
7. **Adaptation strategies to cope with adverse impacts of long-term changes in climate including water availability and sea level rise on the Lower Lakes and Coorong.**

3.3 Ensuring environmental targets are implemented at the catchment scale to achieve objectives

When preparing long-term watering plans for each valley, section 8.20 (2) of the Basin Plan requires states to have regard to the Basin-wide environmental watering strategy that was prepared by the Murray-Darling Basin Authority in 2014 with quantified targets at the Basin scale. These targets need to be clearly integrated into long-term watering plans so they can be implemented and monitored at the catchment level. For example, the Basin-wide targets for forests and woodlands are to maintain the current extent of forest and woodland vegetation at 360,000 ha of river red gum, 409,000 ha of black box and 310,000 ha of coolibah. These are specified for regions in the Basin (Table 14).[27] Once aligned, achievement of targets at the catchment level should result in achievement of targets at the Basin scale. These targets need to be incorporated into regional plans as part of the water resource plan accreditation process.

The solution is to align the Basin Plan targets, the Basin-wide environmental watering strategy, and water resource plans, at the catchment level as part of the accreditation process. Environmental flows recovered under the Basin Plan should be used to achieve the ecological outcomes specified.

Table 14. The Murray-Darling Basin Authority's estimate of expected extent outcomes for communities of water-dependent vegetation as a result of the Basin Plan.[27]

Basin region	Outcomes for water-dependent vegetation	Area of river red gum (ha)*	Area of black box (ha)*	Area of coolibah (ha)*	Shrublands	Non–woody water-dependent vegetation
Paroo	Maintain extent and condition of water-dependent vegetation near river channels and on the floodplain	2,300	38,300	22,800		Closely fringing or occurring within the Paroo River
Warrego	Maintain extent and condition of water-dependent vegetation near river channels and on the floodplain	7,300	80,400	121,400		Closely fringing or occurring within the Warrego, Langlo, Ward & Nive rivers
Nebine	Maintain extent and condition of water-dependent vegetation near river channels and on the floodplain	200	28,800	15,400		Closely fringing or occurring within the Nebine Creek
Condamine–Balonne	Maintain extent and condition of water-dependent vegetation near river channels and on areas of the floodplain	11,500	36,100	62,900	Lignum in Narran Lakes	Closely fringing or occurring within the Condamine, Balonne, Birrie, Bokhara, Culgoa, Maranoa, Merivale & Narran rivers
Moonie	Maintain extent and condition of water-dependent vegetation near river channels and on the floodplain	2,200	2,500	7,900		Closely fringing or occurring within the Moonie River
Border Rivers	Maintain extent and condition of water-dependent vegetation near river channels and on areas of the floodplain	10,700	3,800	35,200	Lignum in the lower Border rivers region	Closely fringing or occurring within the Barwon, Dumaresq, Macintyre rivers & Macintyre Brook
Gwydir	Maintain extent and condition of water-dependent vegetation near river channels and on low-lying areas of the floodplain.	4,500**	600	6,500	Lignum in the Lower Gwydir	Closely fringing or occurring within the Gwydir River and marsh club-rush and water couch in the Gwydir Wetlands
Namoi	Maintain extent and condition of water-dependent vegetation near river channels.	6,100	800	4,200		Closely fringing or occurring within the Namoi River
Macquarie–Castlereagh	Maintain extent and condition of water-dependent vegetation near river channels and on low-lying areas of the floodplain	58,200	57,100	32,200	Lignum in the Macquarie Marshes	Closely fringing or occurring within the Bogan, Castlereagh, Macquarie and Talbragar rivers; and common reed, cumbungi and water couch in the Macquarie Marshes
Barwon–Darling	Maintain extent and condition of water-dependent vegetation near river channels and on low-lying areas of the floodplain	7,800**	11,700	14,900		Closely fringing or occurring within the Darling River

Lachlan	Maintain extent of water-dependent vegetation near river channels and on low-lying areas of the floodplain. Improve condition of black box and river red gum	41,300	58,000		Lignum in the Lower Lachlan	Closely fringing or occurring within the Lachlan River and Willandra Creek; and common reed and Cumbungi in the Great Cumbung Swamp
Murrum-bidgee	Maintain extent of water-dependent vegetation near river channels and on low-lying areas of the floodplain. Improve condition of black box and river red gum	68,300	38,900		Lignum in the Lower Murrumbidgee	Closely fringing or occurring within the Murrumbidgee River, Billabong and Yanco creeks
Lower Darling	Maintain extent of water-dependent vegetation near river channels and on low-lying areas of the floodplain. Improve condition of black box and river red gum	10,300	38,600	600	Lignum swamps in the Lower Darling region	Closely fringing or occurring within the Darling River, Great Darling Anabranch and Talyawalka Anabranch
Ovens	Maintain extent and condition water-dependent vegetation near river channels and on the floodplain	10,200	<100			Closely fringing or occurring within the Ovens River
Goulburn–Broken	Maintain extent of water-dependent vegetation near river channels and on low-lying areas of the floodplain. Improve condition of black box and river red gum	19,800	500			Closely fringing or occurring within the Broken Creek, Broken and Goulburn rivers
Campaspe	Maintain extent and condition of water-dependent vegetation near river channels	1,900	<100			Closely fringing or occurring within the Campaspe River
Loddon	Maintain extent and condition of water-dependent vegetation near river channels	2,200	700			Closely fringing or occurring within the Loddon River
Murray	Maintain extent of water-dependent vegetation near river channels and on low-lying areas of the floodplain. Improve condition of black box and river red gum.	90,600	41,700		Lignum along the Murray River the Wakool River to downstream of Lock 3	Closely fringing or occurring within the Murray, Edward, Kiewa, Mitta Mitta, Niemur and Wakool rivers and Tuppal Creek; *Ruppia tuberosa* in the Coorong and Moira grasslands in the Barmah– Millewa Forest
Wimmera–Avoca	Maintain extent of water-dependent vegetation near river channels. Improve condition of black box and river red gum.	6,500	3,100			Closely fringing or occurring within the Avoca, Avon, Richardson and Wimmera rivers
Eastern Mt Lofty Ranges	Maintain extent and condition of water-dependent vegetation near river channels	<100	<100			

4. A regional development package that puts communities at the centre of reform

National water reforms since 2004 have brought a range of direct and indirect benefits to the irrigation industry, however some communities have been adversely affected and there is inadequate support for regional communities most affected by water reform. Impacts of water reform have compounded long-term changes in social and economic structure of some regional communities as a result of influences such as drought and mechanisation of agriculture. Impacts of water recovery are more acute for those communities with greater dependence on irrigated agriculture and less diversified economies.[91]

Water reforms have failed to provide adequate support for communities most adversely impacted by the Basin Plan. Under the current reforms, only those with water to sell will receive financial compensation, and only irrigators will benefit from infrastructure improvements. Less than one per cent of the $13 billion has been made available to assist communities to adapt to a future with less water. Well-coordinated irrigation groups have used this failure to lobby governments to halt water recovery, at the expense of Basin communities and river health.

Different solutions will be required in different locations. Community representatives are best placed to advise governments on the support that is required. Commonwealth and state governments need to work directly with all relevant community leaders, local governments, regional development boards and natural resource management agencies in an equitable and transparent way to implement the Basin Plan in the best interest of the community as a whole. With just $500 million, or 10% of the remaining $5.1 billion, it is possible to implement the Basin Plan in full while delivering a regional development package to assist communities to manage the necessary transition.

Successful water reform requires supporting communities likely to be adversely affected by water reforms by investing in social and productive capital that assists these communities to adapt to a future with less water.[191] Solutions for regional development can include restructuring industries as a whole, providing specific assistance to individual businesses, assisting with the labour market, and investing in new economic opportunities.[192] A regional development package could also include investment in other non-water infrastructure (e.g. internet, education, transport) to support new economic opportunities, decentralisation of public services, and a regional development fund from which community groups can bid for projects. In addition to the direct economic benefits, these initiatives can also improve the resilience of communities to adapt to changing conditions such as market volatility, climate change and demographic change.

A regional development package could build upon work already underway in the Basin. For example, in 2015 the Regional Australia Institute and the Namoi Joint Organisation of Councils identified the drivers shaping the future of the region over the next 10 to 15 years.[193] Six factors were identified that were likely to have the greatest influence on the future of the Namoi region: national and global cycles in commodity markets; maximising innovation in agricultural production; seeking international investment, on the right terms; engaging the Namoi in major overseas markets; urbanisation; and leveraging regional/brand marketing to attract people to live and work in the Namoi.

In 2016, a statutory advisory committee to the Murray-Darling Basin Authority consisting of community representatives from the northern Basin put forward four priority areas for structural adjustment. They recommended:

- supporting individuals to reskill, relocate and find employment;
- assisting businesses to build capacity and diversify;
- providing low interest loans to assist restructuring and adaptation; and
- developing exit strategies and covering relocation costs.

Such models could be the basis for a regional development program and replicated more widely throughout the Murray-Darling Basin where reform is needed for triple bottom line outcomes.

The solution is for COAG to agree to a regional development package that puts communities at the centre of reform, by:

- **Assisting communities most affected by water recovery to restructure their economies to adapt to a future with less water. Assigning for example, 10% of the remaining $5.1 billion would release up to $500 million for regional development initiatives.**
- **Linking public funding directly to the Basin Plan, by the Commonwealth working directly with community leaders, local government, regional development boards and natural resource management agencies to recover water in a manner that optimises regional development opportunities for those communities.**

5. Prepare for the prospect of a future with less water.

Global demand for food, energy and resources is predicted to rise in the 21st century and the Murray-Darling Basin's industries can benefit significantly. The world will need to increase food production by 70 percent compared to 2007 levels if it is to feed the 9.1 billion people projected by 2050.[194] Almost half of this demand will come from China's rising middle class and their demand for high quality agriculture and food products.[195] As a global leader in water management, Australia is well placed to harness the demand and build global capacity for food, energy and water security. In a world of increasing resource constraints, the challenge for Australia is to produce more food with less land and less water. This requires (1) an improved understanding of potential future stresses on water resources such changes in rainfall and runoff induced by climate change, (2) integrated management of land and water resources, (3) investment in knowledge and capacity for sustainable agriculture, and (4) a reinvigorated national water reform agenda.

5.1 Improve scientific understanding of potential future stresses

Australia is the driest inhabited continent and flows in the Murray-Darling Basin are among the most variable in the world. Climate change will compound existing pressures on water resources, with significant shifts in temperature and precipitation predicted across the Basin by 2030. The Basin Plan does not directly address the risks of climate change on water availability and river health,[51, 196] and there is no information on the effectiveness of the Plan to cope with long dry periods such as that experienced throughout the Basin during 1997 to 2009. This leaves business and communities with no clear policy setting or process to manage the anticipated changes in water availability into the future. It also places ecosystems across the Basin at risk. As part of upcoming reviews of the Basin Plan there is an obligation for government to consider the "management of climate change risks and include an up-to-date assessment of those risks" (s6.06 (3)). There is much groundwork to do in improving scientific understanding of potential stresses, in preparation for incorporating climate change into the Basin Plan in the future.

5.1.1 LONG-TERM IMPACTS OF CLIMATE CHANGE

The Wentworth Group commissioned an assessment of the best available science into how climate change is affecting and likely to affect the health of the Murray-Darling Basin in the future (see Appendix 4). We reviewed the implications of climate change in the Basin using CSIRO's latest climate change projections, and assessed the continuing relevance of the detailed hydrological climate change projections for the Basin provided by Murray-Darling Basin Sustainable Yields project in 2008.[197] The wet and dry extreme climate scenarios used in the 2008 Sustainable Yields were assessed as still valid and representative given latest science, and thus the consequent hydrological scenarios are similarly still valid and representative. However, we note that latest climate modelling results suggest that the probability of the dry scenario may have declined slightly.

The Basin has warmed by nearly 1 degree on average since 1910 and temperatures are projected to increase by another 0.6 to 1.5 degrees Celsius by 2030 relative to 1995 and by between another one to two (0.9 to 1.9) degrees Celsius by 2050 without mitigation (Figure 32).[198] There is medium confidence that more time will be spent in drought across the Basin in the future, as defined in terms of rainfall deficits. The changes largely follow the projected changes to mean rainfall which could increase or decrease, but a decrease is more likely.

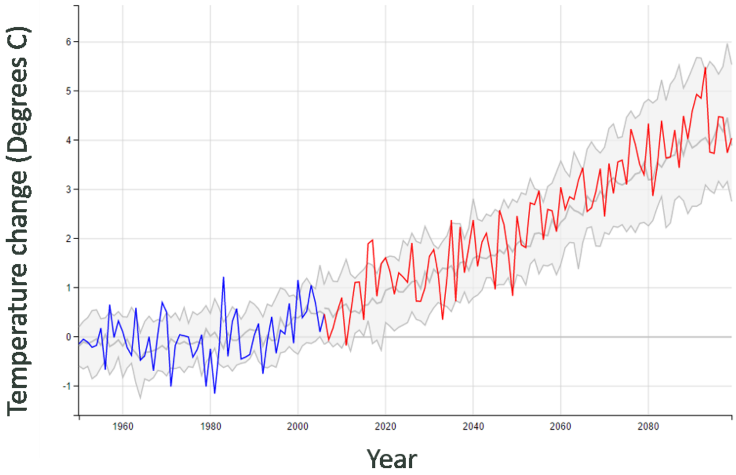

Figure 32. Example of model simulated historical (blue) and projected (red) annual temperature (in Celsius) for Murray Basin region from a single global climate model (ACCESS-3 model, RCP8.5). Grey envelope indicates results from multiple models. Projected warmings in the text are based on multiple climate models. Source: Time Series Explorer, Climate Change in Australia.[199]

Annual average rainfall in the southern Basin is expected to change by between -11% and +5% by 2030 from 1995 levels while rainfall in the northern Basin is projected to change by -13% to +8%.[199] By 2050, these ranges are around -17% to +8% and -16% to +11%. An example of how a rainfall decline could unfold in a drying model is illustrated in the results for one model in Figure 33.

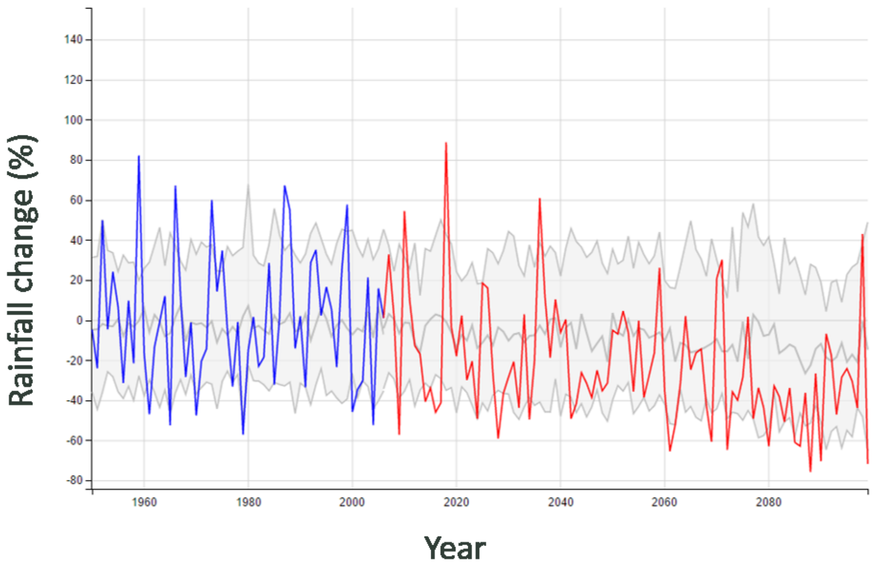

Figure 33. Example of modelled historical (blue) and projected (red) winter precipitation anomaly (in %) for the southern Basin region from a single global climate model (GFDL-ESM2M model, RCP8.5). Grey envelope indicates results from multiple models. Source: Time Series Explorer, Climate Change in Australia.[199]

Any reduction in precipitation is likely to have significant impacts on water flows in rivers (Figure 34), in some cases driving a threefold reduction in runoff.[200, 201] For example, a 10% decline in rainfall could result in a 30% reduction in streamflow. Averaged across the Basin, annual average runoff is predicted to decline by 33% in the dry scenario and increase by 16% in the wet scenario by 2030.[197] Changes to runoff in the southernmost catchments are around -40% to little change, and between -30% and +30% in the northern catchments. The dry scenario reduces flow more strongly in winter, and the wet scenario increases flows more strongly in summer. Modelled impact on water supply for Victoria, which used the latest climate models, show runoff reductions which are somewhat less weighted to decreased runoff,[202] whilst still broadly consistent with the reductions in runoff modelled in CSIRO's Sustainable Yields in 2008.

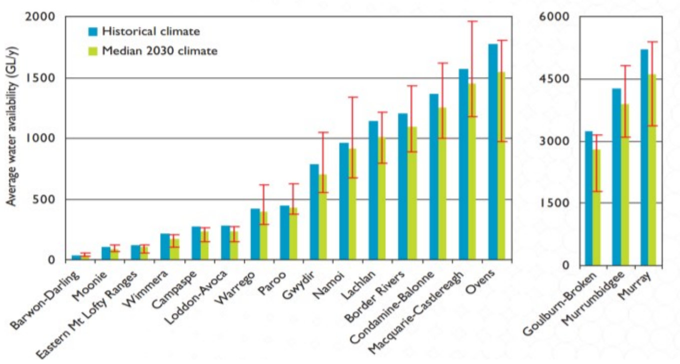

Figure 34. Average surface water availability in GL/yr for regions in the Murray-Darling Basin. Historical and median future climate for 2030 shown in bars, and the wet and dry scenarios by the red bar. Source: Reproduced from CSIRO.[197]

Extreme daily rainfall is very likely to increase in magnitude, and with it the risk of increased flooding and erosion. Projected warming is also associated with increased potential evapotranspiration, increased bushfires and reduced soil moisture across the Basin.[198] Higher temperatures lead to less precipitation likely to fall as snow, and faster snow melt,[203] resulting in changes to the seasonality of river flows. Water-dependent species with narrow ranges of environmental tolerances are most likely to be disadvantaged, and this would be exacerbated in wetland systems as connectivity between freshwater habitats is reduced.

Using a climate analogue approach to describe how these changes may affect the Murray-Darling Basin, generally speaking, sites 'move' inland/northwest under the hottest/driest scenario and north/northeast in the coolest/wettest scenario. The climate analogues for range of selected sites in the Murray-Darling Basin are listed in Table 15 and mapped in Figure 35. In 2050 under the highest emission scenario, climate analogues may be many hundreds of kilometres away in areas of differing agricultural production and sometimes outside the Basin.

In summary, the Murray–Darling Basin has already experienced changes in temperature and rainfall, and is vulnerable to future climate changes, especially in the southern catchments. A priority in future Basin planning should be preparing the Basin for future droughts and other climate change impacts.

Table 15. Climate analogue sites for nine locations in the Basin under the climate scenarios indicated. Temperature and precipitation changes indicated for each MB (Murray Basin) and CS (Central Slopes). Source: Climate Analogues Explorer, Climate Change in Australia website.[199]

	Hottest and driest 2030 RCP4.5* MB, +1.1 C, -7% CS +1.1 C, -9%	Coolest and wettest 2030 RCP4.5* MB, +0.9 C, 0% CS. +0.9 C, 10%	Hottest and driest 2050 RCP8.5* MB, +2.1 C, -21% CS, +2.5 C, – 20%	Coolest and wettest 2050 RCP8.5* MB, +1.3 C, 8% CS +2.0 C, 7%
Bendigo	Kyabram	Corowa	Griffith Leeton	Wagga Wagga, Cootamundra
Griffith	Hay, Balranald	Cobar	Ivanhoe	Condobolin
Wagga Wagga	West Wyalong, Condobolin	Parkes Forbes	Griffith, Cobar	Dubbo, Parkes
Forbes	Condobolin	Gilgandra	Nyngan, Cobar	Gunnedah, Scone
Renmark	Port Augusta	Menindee	Leigh Creek	Menindee
Dubbo	Coonamble	Gunnedah	Nyngan Lightning Ridge	Narrabri Moree

Goondiwindi	Roma	Gaydnah	Tambo	Collinsville
St George	Charleville	Taroom	Barcaldine	Charters towers Emerald
Moree	Roma St George	Goondiwindi.	Tambo Charleville	Gayndah

**The RCPs comprise: RCP8.5 (high emissions and thus greatest impact on the climate), RCP4.5 and RCP6.0 (intermediate emissions and climate impact) and RCP2.6 (low emissions and least climate impact).[204] The RCP8.5 future involves little reduction to current emission patterns, whereas at the other extreme, RCP2.6 represents a very ambitious program where emissions peak by 2020 and decline rapidly after that to eventually less than zero. See further discussion in CSIRO & BoM.[198] Results presented here are primarily for RCP4.5 and RCP8.5.*

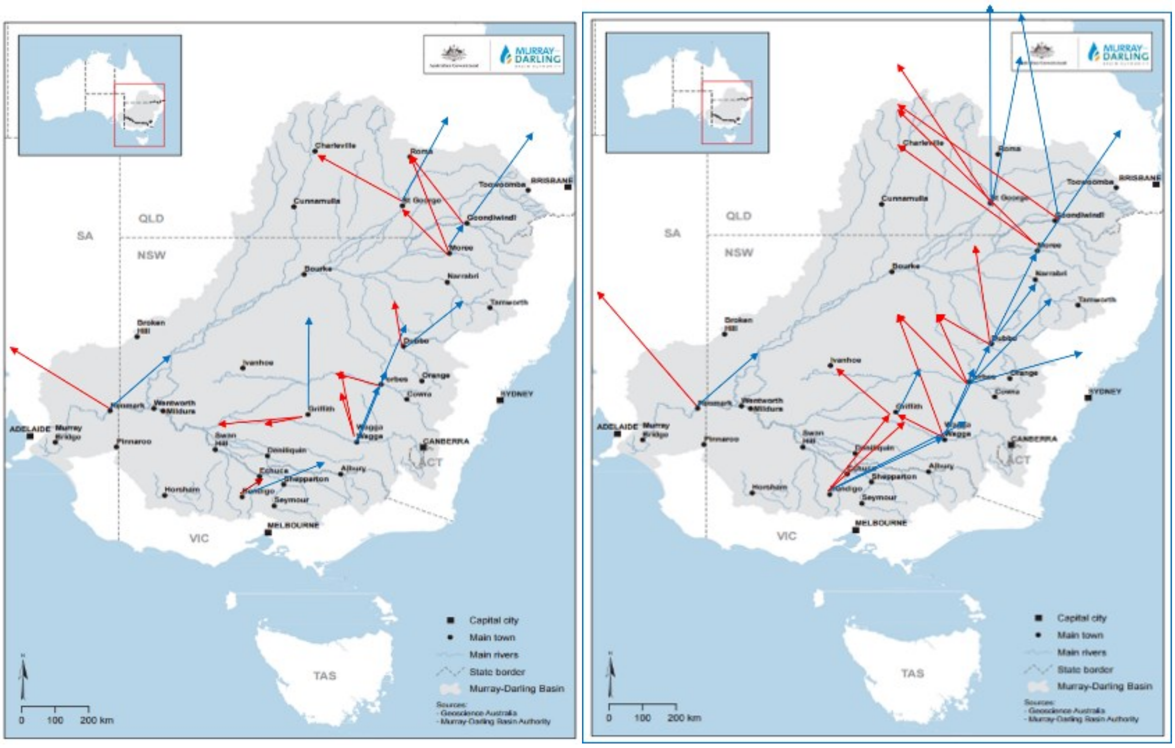

Figure 35. Map depiction of the climate analogues. Left panel 2030 and right panel 2050. Red arrows show the hottest and driest case, and blue arrows show the coolest and wettest case.

5.1.2 INCORPORATING CLIMATE CHANGE INTO THE BASIN PLAN

When the Basin Plan was adopted, the Murray-Darling Basin Authority accepted the climate change risk sharing that is embedded in existing State water resource plans, in order to preserve the reliability of entitlements.[205] Under this approach, water entitlement holders are better protected from any reduction in water availability due to climate change than non-entitlement users.

The environment bears a greater burden of reduced flows under climate change. As water becomes scarcer in the Basin, environmental water is reduced by about four times as much as reductions in surface water extractions by irrigators.[206] This is illustrated in the Murrumbidgee River during the last drought where water sharing rules resulted in negligible outflows into the River Murray between 1994 and 2005 while irrigation diversions remained above 1,500 GL (Figure 36). Planned environmental water is particularly vulnerable because it is not well protected and consists of 70-80% of the water available. CSIRO (2008) concluded “this policy represents a significant risk to the environment”.[207]

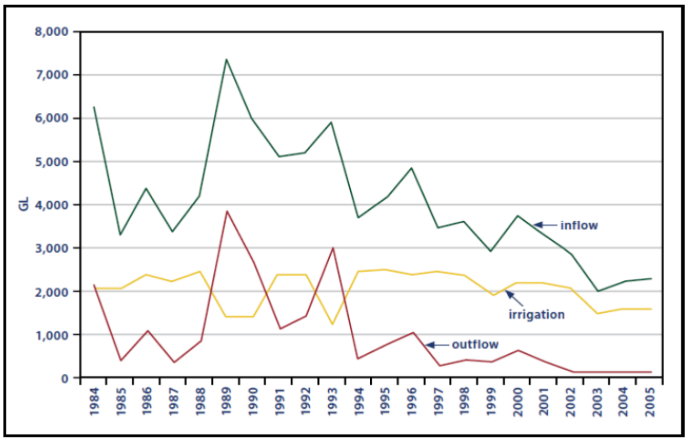

Figure 36. Murrumbidgee River inflow, outflow and water used for irrigation from 1984 – 2005.[208]

There is a need to re-assess management of water resources in light of the impact of climate change on water availability (see page 68). In 2016, the Victorian Government published guidelines for assessing the impact of climate change on groundwater resources, drought and operational planning, alternative water supply projects and demand projections.[202] The guidelines present four climate change scenarios in a risk based framework that considers the vulnerability of supply systems to climate variability and climate change. The report recommended "water corporations must assess the impact of climate change when developing long-term projections of water availability".

A robust way to rebalance the climate change risk is to periodically re-assess sustainable diversion limits under climate change projections and use the results as the basis for new sharing arrangements.[205] This approach enables environmental objectives and targets to be assessed within the envelope of projected water availability. A first step is to select the appropriate climate scenarios and prepare future flow projections. New modelling may be required as CSIRO Sustainable Yields projections do not extend beyond 2030.

5.1.3 DEVELOPING AN ADAPTATION FRAMEWORK

Governments need a framework to address long-term issues associated with climate change in the Murray-Darling Basin, including consideration of the impacts of sea level rise on the Murray mouth and barrages. A climate change adaptation framework would bring together communities and experts to agree on values to be conserved in the future (social, economic and environmental), identify thresholds for conserving these values, and determine triggers for changes in strategy.

Scenario planning is useful for 'stress testing' the Basin Plan in climate extremes, and addressing opportunities and risks under different futures. Scenario planning can also assist with understanding the necessary decisions, the lifetimes and flexibility of these decisions, and optimising short and long-term outcomes.[209]

A wide range of adaptation measures should be considered, including options that sit beyond the water sector. Tools such as the Climate Assessment Framework can be used to identify low risk adaptation measures, and adaptation pathways under different scenarios of future change. The adaptation potential of all management activities should be evaluated over the appropriate time scales. For example, the adaptation potential of floodplain infrastructure should be assessed over its economic life while the adaptation potential of environmental watering plans should be considered over their statutory time span.

COAG needs to agree to improve the scientific understanding of the potential future stresses caused by extreme weather events (e.g. more frequent and more severe drought and higher evaporation from rising temperature) and long-term changes in climate including water availability, supported by a climate change adaptation program for environmental assets, industries and public infrastructure.

5.2 Expand the mandate of the Basin Plan

Environmental water is a pre-requisite for restoring the health of the Basin's river systems but river health depends on more than just flow. Natural resource management measures are also important for delivering a healthy river system to complement (and not substitute for) water management. Measures include direct interventions such as invasive pest control and thermal pollution control, through to improved management systems such as riparian forest buffer zones, regional strategic planning and freshwater protected areas. The Basin Plan in its current form does not sufficiently incorporate natural resource management activities, nor does it control land use which is regulated by states, nor does it give the Commonwealth sufficient powers to effect changes to the broader planning and management frameworks in the Basin. Future iterations of the Murray-Darling Basin Plan should expand its mandate to deliver integrated land and water management including management of environmental water.

The Commonwealth needs to expand the mandate of the Basin Plan to integrate water planning with broader natural resource management to improve the overall environmental condition of the Basin.

5.3 Invest in knowledge and capacity

Australia is well placed for research excellence on agriculture, food security, catchment health and water supply systems in a variable and changing climate. As an international leader in water management and with best practice agriculture, Australia has opportunities to export this knowledge to countries globally who are grappling with the challenges of increasing competition over resources and food security. However, there has been a stagnation in research, development and extension services by federal and state agencies over past few decades (Figure 37). Organisations such as CSIRO and universities have cut their investment in field based services capable of advancing our competitiveness and sustainability across the triple bottom line.

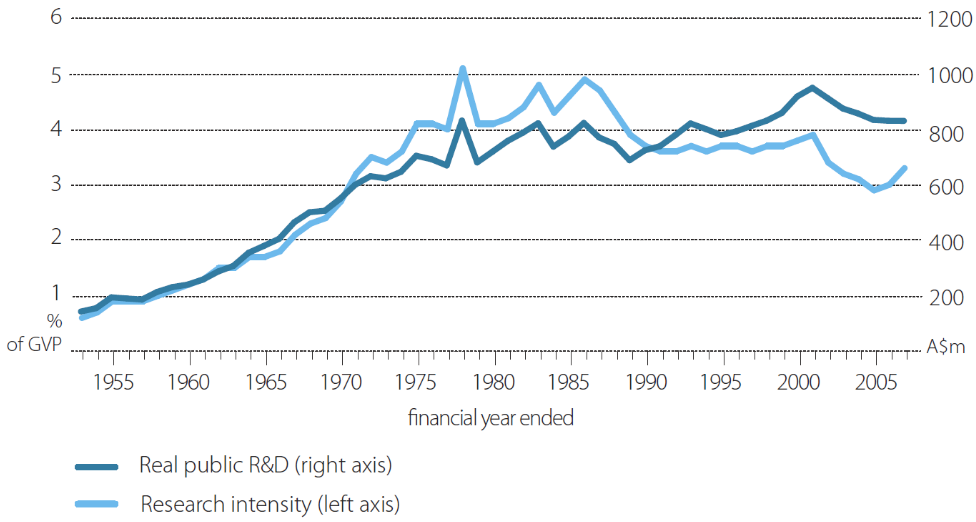

Figure 37. Real public research and development investment and research intensity (expressed as a percentage of gross value of agricultural production; GVP) in Australian agriculture, 1952-53 to 2006-07. (Source: Sheng et al, 2011)[210]

Research stations could offer assistance to farmers and others who seek to capture environmental benefits that underpin natural values and ecosystem services. For example, the Loxton Research Centre in South Australia has played a pivotal role establishing the horticulture sector since the early 1960s, and continues to support the growth of the premium food and wine industry. One option is to expand this model into a network of facilities across the Basin to provide an integrated approach to agricultural services, and in doing so, boost economic productivity and sustainability. Research programs could encompass fields such as agricultural science, farm management, ecosystems and climate change. Stations could support farm-based programs with landowners to demonstrate innovations such as new crops, grazing techniques and irrigation technology. Partnership with the agri-business sector can provide mutual benefits and help raise the profile of sustainable agriculture in Australia and overseas.

Governments should invest in knowledge and capacity to enhance agricultural productivity, sustainable production and food and water security, and protect the natural resource base in a variable and changing climate.

5.4 Reinvigorate national water reform effort

This review has demonstrated that progress has been made in many aspects of water reform in the Murray-Darling Basin. Unprecedented volumes of water have been recovered for the environment from consumptive use, environmental outcomes are being realised where this water is used, and significant investment has been made in modernising irrigation infrastructure. There has also been considerable improvements in the governance of water markets, which has led to irrigation water resources moving to higher value uses.

Other aspects of water reform in Australia have lost momentum and, in some cases appear to be in retreat. The COAG Standing Council on Environment and Water, the peak body for coordinated government action on water reform, was disbanded in 2013 without replacement, and the Sustainable Rivers Audit was abandoned in 2012. The independent review body, the National Water Commission, was abolished in 2014 and responsibilities were split amongst government agencies, leaving the "potential for diminished commitment to the [National Water Initiative] reform agenda" according to the Commonwealth Government's 2016 State of the Environment Report.[50] This Report also found that "progress has slowed in areas such as development of comprehensive water plans, improvements in sustainable water use, standardisation and nationalisation of water markets, and broader adoption of water accounting".[50] The erosion of the national capacity to monitor water reform has made for a difficult policy environment for implementing and progressing reforms in the Murray-Darling Basin. With growing demand for agricultural products[211] and increased risks from climate change, Australia urgently needs to reinvigorate the national water reform agenda to prepare the nation for the opportunities and challenges that lie ahead.

Basin governments should ensure water reform remains a permanent item on the COAG agenda, and recognise the long-term nature of national water reform via the establishment of an independent expert body to undertake regular reviews of progress.

Glossary

Allocation Water that is available to use or trade in any given year, often quoted as a percentage of the volume of each entitlement. For example, a 20% allocation in a particular season allows a water user with a 100 ML entitlement to take 20 ML of water.

Basin states For the purposes of the Basin Plan, the basin states are defined in the Commonwealth Water Act 2007 as New South Wales, Victoria, Queensland, South Australia and the Australian Capital Territory.

Carryover A way to manage water resources and allocations that allows irrigators to take a portion of unused water allocation from one season into the new irrigation season.

Constraint Impediment to the delivery of environmental water. Constraints can include physical features such as low lying bridges, or river channel capacity, but can also include policies and river management rules that impact on when and how much water can be delivered.

Constraints measure A measure which removes or eases a physical or other constraint on the capacity to deliver environmental water; and when combined into a package of supply, efficiency and constraint measures, allow environmental water to be used to maximum effect.

Consumptive use Use of water for irrigation, industry, urban, stock and domestic use, or for other private purpose.

Diversion Water that is taken from a water source for consumptive use.

Easement A grant of rights to deliver environmental flow over private land.

Efficiency measure Measures which provide more water for the environment by making water delivery systems for irrigation more efficient. This can include replacing or upgrading on-farm irrigation, or lining channels to reduce water losses within an irrigation network.

Entitlement A right to use water from a defined water source. Entitlements have different characteristics depending on where and how water is taken.

Environmental flow Any river flow pattern provided with the intention of maintaining or improving river health.

Environmental water requirements The amount of water needed to meet an ecological or environmental objective.

Environmental water (or environmental flow) Water used to achieve desired outcomes for the environment, including for ecosystem functions, biodiversity, water quality and water resource health.

Equivalent (or ecologically equivalent) Environmental outcomes which are commensurate with the outcomes achieved through environmental water but are achieved using measures aside from additional flows (e.g. evaporative savings, re-operating storages).

Floodplain harvesting The collection or capture of water flowing across floodplains for consumptive use.

Held environmental water Water that is available under a water access entitlement for the purpose of achieving environmental outcomes.

Interception Capture of run-off from human activities (e.g. plantations, farm dams, levees) before it reaches rivers and streams, which can reduce the flow of water in waterways.

The Living Murray program A 12 year partnership between the Murray-Darling Basin Authority and the New South Wales, Victorian, South Australian and Australian Capital Territory Governments established in 2002. Through a $650 million investment, the program has acquired almost 500 GL of environmental water and constructed a series of water management structures to be used for environmental watering of floodplains and wetlands.

Off-farm infrastructure modernisation Improvement of channels, pipes, pumps, meters, off-stream storages and aquifer storage and recovery, from the source (headworks on a river, storage reservoir or well head) to irrigator off-take.

On-farm infrastructure upgrades Upgrades of privately owned channels, pipes, pumps, meters, off-stream storages after the irrigator off-take.

Planned environmental water Water committed to the environment by rules in state water resource plans

Regulated A water system in which water is stored or flow levels are controlled through the use of structures such as dams and weirs.

Salt interception scheme Large-scale groundwater pumping and drainage projects that intercept saline groundwater inflowing to rivers, and dispose of the saline waters by evaporation and aquifer storage at more distant locations.

Shepherding (of environmental water) Delivery of a volume of environmental water available in one part of the river system to a more downstream location.

Supply measure A measure that either (1) increases the quantity of water available to be taken (e.g. by streamlining river operations or management rules) or (2) achieves equivalent environmental outcomes with less water than would otherwise be required (e.g. by building or improving river or water management structures so environmental water can be delivered directly to places that need it more or those which can achieve the best outcomes).

Surface water Includes water in a watercourse, lake or wetland, and any water flowing over or lying on the land after having precipitated naturally or after having risen to the surface naturally from underground.

Sustainable diversion limit The maximum long-term annual average quantity of water that can be taken for consumptive use, on a sustainable basis, from the Murray-Darling Basin’s water resources. Sustainable diversion limits will operate from 2019 and will replace the cap system.

Sustainable diversion limit adjustment mechanism Allows the sustainable diversion limit to be adjusted under certain circumstances.

Unregulated river A river system without major dams and weirs.

Water resource plans Statutory management plans developed for particular surface-water and groundwater systems, currently known by different names throughout the Murray–Darling Basin (e.g. 'water sharing plans' in New South Wales and 'water allocation plans' in South Australia).

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